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Math Leaders' Perceptions of Social Justice Pedagogy: Implications for Professional Development on Teaching Mathematics for Climate and Environmental Justice

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Math Leaders' Perceptions of Social Justice Pedagogy: Implications for Professional Development on Teaching Mathematics for Climate and Environmental Justice

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

by

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Ecclesiastes 3:1

DEDICATION

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Two significant crises facing communities of color are climate and environmental injustices (Schlosberg & Collins, 2014) and the achievement gap in standardized test performance as an impact of inequitable educational experiences rooted in a history of social inequities (Agarwal, 2011; Milner, 2020). Previous studies on teaching mathematics for social justice demonstrate positive impacts on performance outcomes and the development of positive student mathematical identities (Berry, 2008; Gutstein, 2006). Existing literature also points to the benefits of focusing on a specific social justice topic during mathematics instruction and over a more extended period of time (Bartell, 2013; Stocker, 2012). However, few studies focus on teaching mathematics for climate and environmental justice (TMCEJ). Furthermore, few studies explore the perceptions of math leaders regarding implementing this work and supporting teachers in the classroom.

This study applied a basic qualitative research design to explore math leaders' social justice pedagogical practices and perceptions of professional development needs for a TMCEJ initiative. Critical Race Theory (CRT) was the theoretical framework applied to this exploratory

study because it supports researchers in placing race central to the research (Delgado & Stefancic, 2017). The participants for this study comprised five Title I math leaders who worked in five districts across a mid-Atlantic state and engaged in social justice pedagogy as classroom teachers.

Tentative conclusions revealed that math leaders could support students in engaging mathematics to identify operative social constructs. However, few stories demonstrated discussions progressing to forms of student activism. This exploratory study also revealed that while the existing educational structure is not intended to support social justice pedagogical practices, math leaders had recommendations for navigating educational domains. Math leaders also shared favorable perceptions of a TMCEJ initiative and professional development considerations for this initiative despite the limitations of the state-mandated curriculum. Practical and theoretical implications are presented and future research recommendations to support the implementation of a TMCEJ initiative are also proposed.

CHAPTER 1: INTRODUCTION

Two important crises facing communities of color are climate and environmental injustices (Schlosberg & Collins, 2014; Kluttz & Walter, 2018) and the achievement gap in standardized test performance as an impact of inequitable educational experiences (Agarwal, 2011; Milner, 2020). Climate and environmental injustices have significant repercussions for communities of color, yet academic scholarship primarily focuses on climate injustice and its unfair burden on future generations (Black, 2016; Shelby & Kagawa, 2018). A generational focus on climate injustice excludes the voices and experiences of historically underrepresented groups who contribute the least to the causes of global warming but experience the most significant adverse impacts (Kluttz & Walter, 2018; Schlosberg & Collins, 2014). This disproportionate impact occurs because "the chemicals that are polluting communities, displacing families and literally killing people are the same chemicals that are causing the planet to warm at alarming rates" (PBS, 2019, 1:00). Existing inequities in who suffers the most from climate and environmental changes in the United States will worsen unless intentional actions mitigate climate change (Schlosberg & Collins, 2014).

More overtly prevalent in the narrative of communities of color is the continuous struggle of teachers and students to demonstrate evidence of proficient outcomes in mathematical thinking and discourse that are measured using standardized achievement tests. Math is identified as a core content area in the U.S. educational system and is a major focus of high-stakes testing (ASCD, 2016), with significant implications for students' K-12 trajectory. Most policymakers, key decision makers, and members of the general public perceive high-stakes testing as unbiased and use these data to make decisions and substantiate claims about certain student performance. Decision makers in the educational system use data from standardized

testing to focus and advance conversations about an achievement gap and poor school quality in urban public schools (Branson, 2019; Milner, 2020). However, research suggests that standardized test scores from high-stakes testing are not only biased, but are significantly biased (Koretz, 2008) having significant implications for the K-12 trajectory of students of color.

Statement of the Problem

Curricular and instructional efforts to "close the achievement gap" emphasize students mastering real-world math calculations such as the discount on a pair of Nike tennis shoes or preparing students with basic math skills needed for workplace performance. Math teachers in the U.S. are tasked with planning and delivering math content relevant to students' lived experiences to increase student engagement and positively impact performance on standardized math tests (NCTM, 2000). However, there is a difference between the general real-world application of everyday mathematics and contextualizing mathematics within students' lived experiences. Not discounting the necessity of these functional skills, the focus on critical mathematics supports students in developing the skills to engage in critical conversations that support math inquiry for building student agency and developing positive math identities (Gutstein, 2006).

Research demonstrates favorable outcomes with teaching mathematics for social justice (Gutstein, 2006; Berry, 2008; Gutiérrez, 2008). However, scholars posit more favorable student outcomes when math teachers focus on one specific social justice issue (Bartell, 2013; Stocker, 2012). One of the most pressing yet subtle real-world issues for students in urban public schools is climate and environmental injustices in their communities. Systemic oppression has resulted in members of marginalized communities experiencing climate and environmental injustices that negatively impact their quality of life (Hall, 2016) such as: (a) health problems that emerge from

substandard qualities of living caused by redlining and heat islands; (b) environmental pollutions and toxins; and (c) greater risk of fatality from diseases such as COVID 19 due to pre-existing health conditions. However, most teachers and students are unaware of how the climate crisis disproportionately impacts historically underrepresented groups and the economically disadvantaged (Schlosberg & Collins, 2014; Kluttz & Walter, 2018), who constitute the primary demographics in most urban public schools. Therefore, there is tremendous promise for embedding mathematics instruction in the climate and environmental justice framework because, as Harper (2019) posits, increasing students' interest in social justice issues can support their development in mathematics. Those teachers who attempt to use critical and liberatory pedagogy to engage students can have challenges translating social justice theories into classroom practices (Bartell, 2013; Esmonde, 2014; Gonzalez, 2009). Furthermore, teachers must carefully navigate dominant math content, social justice pedagogy, and administrative responsibilities (Bartell, 2013; Gutstein, 2006). Therefore, it is essential to understand professional development considerations for teaching mathematics for climate and environmental justice (Bartell, 2013; Gonzalez, 2009).

Rationale for Study of Problem

The focus of this exploratory study on mathematics as the content-specific subject has potential value, meaning, and practical application because math is a tool that can help students "better understand the sociopolitical context of one's life" (Gutstein, 2003, p. 40). Previous studies on teaching mathematics for social justice demonstrate positive impacts on student achievement and the development of positive student mathematical identities (Berry, 2008; Gutstein, 2006). The literature on teaching mathematics for social justice in K-12 education has expanded over the past 20 years. However, there remain few studies that focus on teaching

mathematics for climate and environmental justice (TMCEJ). In addition, few studies explore the perceptions of math leaders in regards to implementing this work and supporting teachers in the classroom. Existing literature points to the benefits of focusing on a specific social justice topic during mathematics instruction and over a longer period of time (Bartell, 2013; Stocker, 2012). As such, there is opportunity for considering a system-wide school district initiative to support a TMCEJ initiative. Math leaders offer unique insights into district-wide initiatives specific to mathematics and often influence decisions about curriculum and teacher supports. To this end, this study proposed an examination of math leaders' perceptions of social justice pedagogy and professional development for a TMCEJ initiative.

Statement of Purpose

The purpose of this study was to explore math leaders' former social justice pedagogical practices as classroom teachers to inform professional development centered on TMCEJ. An important aspect of this undertaking was understanding how math leaders navigate administrative responsibilities, dominant math curriculum, and social justice pedagogy. Math leaders' perceptions of navigating the domains were also used to present implications for professional development to support TMCEJ. This research also sought to learn more about math leaders' perceptions of the intersection of climate change, social justice, and mathematics education as an opportunity for teachers to engage their students in critical conversations surrounding these topics that are often part of their students' lived experiences and positively influence student learning outcomes.

Literature / Research Background

The bodies of literature that supported the current study were teaching mathematics for social justice and climate and environmental justice. Climate change impacts all members of

society as it manifests as breaking heat records and historic weather patterns (Schlosberg & Collins, 2014). However, a closer look at social constructs within the phenomenon illuminates extreme concerns because there is a climate and environmental injustice aspect to changing climate and environmental patterns. The negative impacts of these patterns caused by the wealthy and powerful have a disproportionately negative impact on communities of color (Kluttz & Walter, 2018). Climate justice is a movement that has recently gained traction over the past decade yet remains understudied in terms of climate justice education. Environmental justice scholarship addresses the environmental footprint of toxic industries, landfills, and brownfields within proximity of communities of color (Shepherd & KC, 2015). These same industries that create products and services for human consumption, are the primary producers of greenhouse gases (GHG) that are causing climate change in the earth's atmosphere, thus the intersection of climate and environmental injustices. Critical Race Theory (CRT) is the theoretical framework applied to this study on mathematics education and climate and environmental justice because it supports researchers in placing race central to the research and recognizes climate and environment disturbances as front-burner issues for communities of color (Delgado & Stefancic, 2017).

Social justice education is not a new phenomenon, and it is valuable in allowing students to draw from their experiences with social injustice, or those others they know, to make connections to their learning (Brown & Brown, 2011). Social justice conversations in the K-12 educational environment are often situated within a history and social studies curriculum due to the natural examination of social and structural patterns and behaviors within these contents (Agarwal, 2011; Brown & Brown, 2011). It has not been until the past two decades that there has

been an increase in scholarship on teaching social justice, culturally relevant, or critical pedagogy in the math classroom (Bartell, 2013; Berry, 2008; Gutiérrez, 2008; Gutstein, 2006).

Research shows value in the math classroom as the location for students to engage in counter storytelling as a strategy to provide space for them to tell their stories with race and social inequities (Berry, 2008; Gutstein, 2003). According to Esmonde (2014), implementing social justice in the math classroom has value for students when discussions of race and racism are thoughtfully planned. Such a view is also supported by Branson (2019) who suggests that students benefit from the opportunity to analyze data presented to them and make meaningful decisions. Teaching mathematics for social justice scholarship demonstrates value in focusing on one social justice issue at a time to help teachers support students in learning to critically apply mathematics to real-world social issues (Bartell, 2013; Stocker, 2012). Math teachers can support students in quantifying climate and environmental injustices and developing agency that builds mathematical confidence by embracing a curriculum and pedagogy that centers their lived experiences in their learning. This curriculum approach is particularly beneficial because it is at the juncture of math content and real-world investigative application where maximum student learning can occur. Consequently, a district approach is proposed to support teachers in implementing a TMCEJ initiative.

Professional development is an essential component of any structural change to support the common implementation of a program or practice in the school system. The consideration of a social justice pedagogical approach embraces "the teacher as an agent of social change who prepares students to critique dominant social structures and the myths that maintain them" (Viesca, Torres, Barnatt, & Piazza, 2013, p. 98). Key themes in the literature for consideration include the importance of teacher autonomy in how a critical stance is adopted (Milner, 2020),

the consideration of administrative responsibilities in creating a program (Gutstein, 2006), and focusing on the dominant math curriculum during instruction (Agarwal, 2011; Bartell, Wagner, Edwards, Battey, Foote, & Spencer, 2017; Harper, 2019). Instructional planning to support the space for mathematical investigations of social justice requires teachers to successfully navigate the curriculum requirements and social justice content (Bartell, 2013) because students must continue to receive the classic math instruction to demonstrate performance mandated in the educational system (Ladson-Billings, 2009b). Social justice pedagogical considerations help facilitate the application of mathematics education to climate and environmental inequities because a social justice-oriented approach is necessary to consider collective actions that can support the mitigation of climate change (Waldron, Ruane, Oberman, & Morris, 2019). Studies on the application of social justice pedagogy (Berry, 2008; Frankenstein, 1990; Gutstein, 2006) can inform K-12 teachers in TMCEJ with practices to support the development of student agency to impact their mathematical literacy, academic experiences, and community.

Research Questions

This exploratory study aimed to add to existing scholarship on teaching mathematics for social justice by understanding math leaders' perceptions of the navigation of three educational domains: dominant math curriculum, social justice pedagogy, and administrative responsibilities. Furthermore, the study contributed to scholarship on climate and environmental justice education by producing findings on professional development needs and the feasibility of embedding mathematical concepts and goals in a climate and environmental justice framework. Teaching mathematics for social justice is intentionally centering student experiences of the interconnection of social constructs for individual and community empowerment in math education (Gutstein, 2006). A residual impact of this approach is student construction of positive

identities within the content area of mathematics. TMCEJ is intentionally supporting students in using math analyses to visualize and articulate the impact of climate and environmental change. The focus on this social justice topic supports reframing students' mathematical identities while helping them learn about advocacy and activism for their communities. To this end, the research questions that guided this study were:

- RQ1 What stories do math leaders share about social justice practices in math classrooms?
- RQ2 In what ways, if any, do math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities?
- RQ3 What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice?

Definition of Terms

The following terms are defined to aid in contextualization and understanding for this exploratory study.

Administrative Responsibilities – Administrative responsibilities are tasks that accompany teacher responsibilities, including lesson planning (i.e., customizing lesson plans, preparing written documents, gathering instructional resources, analyzing data), student supports (i.e., remediation, calling parents, grading), and meetings (i.e., content, school-based, district).

Climate and Environmental Justice – Climate and environmental justice is restoring and protecting Black, Latinx, and Indigenous Americans and the economically disadvantaged who experience a disproportionate impact from fossil fuel chemicals that pollute the environment and cause global warming. (Hill, 2003; Schlosberg & Collins, 2014; Shelby & Kagawa, 2018)

Climate Justice – Climate justice is protecting and giving a voice to vulnerable populations disproportionately impacted by climate change and returning carbon emissions to safe levels by placing the vulnerable communities' interests before those in the fossil fuel industries. (Schlosberg & Collins, 2014; Shelby & Kagawa, 2018)

Dominant Math Curriculum – Dominant math curriculum is the minimum expectations for what students should know and be able to do in state-mandated math courses. The dominant math curriculum is known as the Common Core State Standards of Mathematics (CCSSM) in most states and is accompanied by standardized testing as the measure of student academic achievement.

Environmental Justice –Environmental justice is the equal protection of the most vulnerable populations from environmental hazards and their involvement in developing, implementing, and enforcing environmental laws, regulations, and policies. (Hill, 2003)

Historically Underrepresented Groups – This term represents persons who identify themselves as of Black, Latinx, and Indigenous Americans. It is used interchangeably throughout this document with the term "communities of color."

Math Leader- Math leaders are individuals who were former classroom math teachers and currently hold a non-instructional leadership positions that oversee K-12 mathematics education. They are considered authorities on math instruction and are usually key decision-makers in mathematics professional development.

Social Justice Education – Social justice education centers students' lived experiences with social injustice to make connections to their learning. (Brown & Brown, 2011)

Teaching Math for Social Justice – Teaching math for social justice is defined as supporting students in using mathematics to: a) critically examine unjust social, political and/or

economic structures; and/or b) consider ways they can participate in transforming these same structures at the local, national, and/or global levels. (Gutiérrez, 2008; Gutstein, 2003; Martin, 2003; North, 2006; Tate, 1995; Westheimer & Kahne, 2004)

Student Agency – Student agency is when students view themselves as capable of having an active role in meaningfully contributing to social change through activities and expressing their voice. (Gutstein, 2006)

Methodology

This exploratory study implemented a qualitative methodological approach to explore math leaders' perceptions of professional development needs to teach mathematics for climate and environmental justice. Qualitative research allows an understanding of the meaning participants' have constructed (Merriam & Grenier, 2019) and the unique voices for identifying patterns in the data (Maxwell, 2013). Furthermore, this methodology allows the researcher to modify the research design in response to changes that may occur during the study (Maxwell, 2013). This form of inquiry resulted in the data needed to produce information about math leaders' perceptions of teaching math for climate and environmental justice to contribute to the field of mathematics education.

A quantitative methodological approach was not utilized for this study because the methodology primarily focuses on yes or no questions and measures of degree. As a more traditional methodology that approaches research from a deductive theory-building frame, researchers often use a quantitative approach with the goal of studying a phenomenon objectively (McMillan, 2016). Considering the exploratory nature of this study and the emphasis on math leader's perceptions, a quantitative study would not have been an appropriate research method.

A basic qualitative research design was applied to this study and has the central characteristic of enabling the researcher to understand what a phenomenon means to those involved (Merriam & Tisdell, 2015). The foundation for this study was built on social justice research with preservice teachers (Bartell, 2013) and the limited understanding of inservice teachers' social justice practices to generate descriptive and interpretive data on how math leaders perceive their work towards the success of students of color in urban schools. This information informed implications for professional development for TMCEJ. This study focused on an exploration of math leaders' experiences with teaching mathematics for social justice, their navigation of pedagogical practices and administrative expectations, and perceptions of a TMCEJ initiative. Consequently, interviews yielded the most relevant information from participants (Merriam & Grenier, 2019).

Purposeful selection was the sampling technique used for this exploratory study because it supported the deliberate selection of participants. According to Maxwell (2013), this sample selection strategy allows the researcher to choose participants who can provide the best information relevant to the research goals that cannot be secured from other selection options. Researchers also use this selection method when there are only a limited number of persons, settings, or activities appropriate for the research study. Participants of a mid-Atlantic state critical conversation group around equity in mathematics received an email from their host organization inviting them to participate in the study via a one-time email invitation to the listserv (see Appendix C for the Study Invitation). Participants who satisfied the selection criteria were also recruited through the researcher’s professional network.

Semi-structured interviews were conducted with math leaders to capture their narratives and counter stories, important critical race methodologies that center race (Dixson & Rousseau,

2005). Counter stories were particularly valuable to this study because they countered the deficit approach and destructive stereotypes of communities of color and their perceptions towards education (Milner, 2020; Viesca et al., 2013). Data were analyzed to extract common themes to identify some implications for a TMCEJ initiative.

Implications

There were implications for this exploratory study on TMCEJ. First, a limited number of mathematics education studies examine climate injustice issues (Waldron et al., 2019). This study contributed to the existing knowledge base about how math leaders engage in critical pedagogy. Second, teacher preparation programs can benefit from understanding how inservice teachers balance the intersections that make up their instructional and administrative responsibilities. Providing preservice teachers with strategies to navigate educational domains could help teachers better prepare to enter the classroom environments to remain for longer durations. Third, there is existing literature that focused on preservice teachers' experience with social justice implementation (Bartell, 2013). This study can help strengthen the body of literature on math leaders' experiences with implementing a social justice pedagogy. Fourth, climate justice education is a newer concept that is receiving a gradual increase in interest. There is little research on climate and environmental justice, math, and urban school systems. This endeavor helps increase an understanding of the necessary knowledge, skills, and abilities for navigating the different aspects of TMCEJ.

This study's outcome can inform decision makers in the K-12 environment of ways to support teachers in navigating math content, liberatory pedagogy, and teaching responsibilities. There is often an increase in student engagement when the math curriculum is made applicable to their experiences (Milner, 2020). Teaching math for climate justice would support positive

mathematical experiences for students in different educational settings. Students from all racial and ethnic backgrounds should experience a curriculum that reflects their lived experiences (Brown & Brown, 2011; Milner, 2020). This curriculum can help dispel stereotypes about Black, Latinx, and Indigenous Americans and benefit teachers by helping them form better relationships with their students as together they experience math as a tool to impact social change versus rules to memorize and algorithms to use for functional purposes.

A possible outcome of this study is better support for teachers. This research may help provide practical guidance for inservice teachers to understand and implement critical pedagogy (Gutstein, 2006). Future research can support students' homogeneous use mathematics to discover the local climate and environmental injustices. Future research could then be used to pilot a specific curriculum for TMCEJ to examine the potential impact on student outcomes by focusing on an asset approach where student performance is measured against their individual growth over time. This study contributes different methods to reach all students, the goal of educational research (Brown-Jeffy & Cooper, 2011).

CHAPTER 2: LITERATURE REVIEW

The contextualization of teaching mathematics for climate and environmental justice (TMCEJ) begins with a brief overview of race and equity in education. The literature review then demonstrates the interconnectedness of the dominant math curriculum, social justice pedagogy, and administrative responsibilities for the critical math leader. Five topics help contextualize the nature of math leaders' navigation of these three educational domains on TMCEJ. These topics that support the conceptual framework for this study are: (a) Critical Race Theory as the theoretical framework for centering the experiences of Black, Latinx, and Indigenous Americans, referenced in this study as historically underrepresented groups; (b) reframing the achievement gap in standardized test performance as the opportunity gap; (c) teaching mathematics for social justice; (d) considerations for a TMCEJ initiative; and (e) professional development to support a TMCEJ initiative. This scholarly review concludes with the presentation of the conceptual framework that guided this study.

Critical Race Theory as Theoretical Framework

Critical Race Theory (CRT) is the theoretical lens applied to this study to understand how math leaders make meaning of their experiences with social justice practices within the urban educational setting with African, Latinx, and Indigenous American students. Furthermore, CRT relates to the specific social justice topic of climate and environmental justice because an understanding of the current injustices of people of color is rooted in their past experiences of social injustice (Bell, 1992). Developed by legal scholars Derrick Bell, Alan Freeman, and Richard Delgado in the 1970s (Delgado & Stefancic, 2017), CRT is the appropriate theoretical lens for this study because it acknowledges race and racism as operative in the educational system (Parker & Lynn, 2002) and highlights issues specific to the field of education, "including

high-stakes testing, affirmative action, hierarchy in schools, tracking and school discipline, bilingual and multicultural education, and the debate over ethnic studies and the Western canon" (Delgado & Stefancic, 2017, p. 173). Researchers who apply a CRT lens are concerned with the illumination of the social construction of race, racial inequities, and a transformation of the relationship between racism and power (Delgado & Stefancic, 2017; Graham, Brown-Jeffy, Aronson, & Stephens, 2011; Tate, 1995).

CRT facilitates centering race in the analysis of human experiences and uncovering racism embedded in practices of climate and environmental injustices--e.g., climate gentrification, heat islands, climate displacement--that have become "front-burner issues" (Delgado & Stefancic, 2017). There are several tenets of CRT that provide the basis for centering the experiences of members of historically underrepresented groups; three of which are applied to this study on TMCEJ. First, CRT scholar's advance racism as endemic in our social experiences, permeating all aspects of society without requiring an analysis to demonstrate racism's presence in a particular context (Harper, 2019; Ladson-Billings, 2013). Second, critical race theorists advance the concept of intersectionality to perform an "examination of race, sex, class, national origin, and sexual orientation and how their combination plays out in various settings" (Delgado & Stefancic, 2017). Third, CRT provides the basis for valuing counter stories of people of color as experiential knowledge without comparison to others' experiences for legitimacy or measure of deficiency (Harper, 2019). Through storytelling as a methodological approach, the counter stories of the experiences of people of color are used to expose racial injustices (Ladson-Billings, 2013).

Gutstein (2016) advances that teaching mathematics for social justice is teaching mathematics for racial justice. Therefore, opportunities are provided for students to "analyze

whether and how racism is implicated in social phenomena and to understand different forms of racism (individual, ideological, structural, and institutional)" (Gutstein, 2016, p. 490). A critical race framework is appropriate for this study because it is not only a commitment to a scholarly contribution, but also a commitment to social action (Dixson & Rousseau-Anderson, 2017). As such, a critical examination of K-12 math reform efforts from the past sixty years illuminates both racial injustices in math education and more recent efforts towards equitable mathematics education experiences.

Math Reform Efforts and the Achievement Gap

The past sixty years mark four periods of major math reforms that focused on restructuring, standard-setting, high-stakes testing, and other measures (Milner, 2020). These reform periods were anchored in conversations that ranged from students in the U.S. K-12 educational system becoming more globally competitive to students becoming more mathematical thinkers (Martin, 2019). Within these periods of math reform were various attempts to acknowledge and address racial inequities in the field of math education, where some of the best-intended efforts risked further marginalization of students of color (Berry, Ellis, & Hughes, 2014). The math reform efforts are applicable to this study on TMCEJ because they explain how and why a difference exists in the mathematical performance of students of color and their counterparts, also known as the achievement gap.

The first wave of mathematics, the New Math Movement of 1958, was prompted by the launch of the first artificial satellite by the Soviets, causing the U.S. government to realize they were behind in their ability to compete scientifically with the rest of the world (Berry, 2018). A significant component of this reform movement was a focus on math education as a means of increasing the global competitiveness of the U.S., but it was not meant for the inclusion

of students of color (Berry, 2018). As such, this time frame is often referred to as the 'era of benign neglect' because educational funding primarily supported programs attended by White males at the expense of marginalized learners (Berry, 2018; Tate, 2001).

The Back-to-Basics reform movement emerged in the late 1960s, returning the focus of math instruction to basic math skills. Higher test scores were used as evidence of student proficiency in mathematics. However, students of color were not performing as well as more affluent and primarily White students on assessments because of the lower quality of cognitive expectations of math instruction received during the earlier math movement. According to Berry (2018), the use of the basic skills test was the first of research studies drawing attention to an achievement gap in math that identified marginalized learners as deficient with negative language, thus reinforcing intellectual inferiority mind frames that existed during and before the Jim Crow era. These testing outcomes were used by policymakers to perpetuate the harmful notion of Black students placing the nation at risk and the need for further educational reform to remediate the mathematically illiterate (Gustein, 2003).

In 1989, The National Council of Teachers of Mathematics (NCTM) published the Curriculum and Evaluation Standards for School Mathematics, generating the third and current period of math reform with a focus on not repeating the social injustices of previous educational experiences (Gutstein, 2003). Shortly thereafter, the No Child Left Behind Act of 2001 was introduced by the federal government as a new form of public school accountability where summative school performance data on standardized tests would serve as the basis of comparing different schools (Bonner, 2011). Equity in mathematics education is defined as student access to high-quality curriculum and highly-qualified mathematics teachers (NCTM, 2014). During the

early period of this wave of math reform, the desired outcomes for all learners were recognized, but the factors needed to create the conditions for equitable opportunities were not addressed.

Therefore, the educational advancement of White students and students of color was impacted by most math reforms (Childs & Johnson, 2018). According to Martin (2019), "Each new wave of mathematics education reform is a self-correction to previous reforms, and each of these reforms has served the racial state in ways that help to maintain mathematics education as an anti-Black space" (p. 462). However, a recent heightened awareness of social injustices in society demonstrates a sociopolitical turn in mathematics education (Gutiérrez, 2013a). NCTM (2020) has published the Catalyzing Change series with recommendations for key stakeholders in the middle school environment to positively impact student achievement that include: (a) de-tracking students to decrease the number of students denied access to instruction needed to become mathematically literate; (b) de-tracking teachers to ensure all students have equitable access to teachers with experience; c) ensuring math instruction is relevant to increase student engagement; and (d) creating common learning experiences around central mathematical concepts.

Applying a critical race lens on the different math reform movements demonstrates how race is operative in the educational system (Parker & Lynn, 2002). The overemphasis on standardized testing is problematic because the data are used to suggest that all students learn in homogeneous environments with equal opportunity and fail to consider the inequitable educational experiences of many students of color (Agarwal, 2011; Berry, 2018; Milner, 2020). Students who are members of lower performing historically underrepresented groups, most negatively impacted by the achievement gap, are labeled high-needs. This label is often imposed on students of color without considering the complexity of factors in and outside of school that

exacerbate performance gaps and student achievement in math (Agarwal, 2011). Goals of current reform efforts should not focus on bridging the achievement gap in standardized test performance; but instead on producing equitable learning environments and experiences that positively impact how they see themselves growing in math and connecting to their mathematical identities (Bush, 2019). Consequently, many scholars recommend changing verbiage that describes the racial and ethnic differences in math achievement. Instead of describing differences in student outcomes as an achievement gap--creating the narrative of the learner bearing sole responsibility for achievement outcomes--scholars recommend describing differences as an opportunity gap, recognizing structural and systemic supports as the cause of differences in student performance (Agarwal, 2011; Milner, 2020).

From Achievement Gap to Opportunity Gap

This study on TMCEJ represented a research agenda with an asset versus deficit approach to student ability and movement away from the common narrative that is often associated with the performance of students of color and the economically disadvantaged (Gutiérrez, 2008; Viesca et al., 2013). The challenge with the achievement gap language is that focus is not placed on the gap in education, but the gap related to race (Gutiérrez, 2008). Consequently, the achievement gap then becomes the source for the judgement of the performance of students of color who are primarily located within urban schools labeled high needs. Milner (2020) proposes a focus on the opportunity gap to recognize the assets and potential of students of color and to disrupt the focus on the use of standardized testing to impose value by which the performance of the "other" student is measured against the performance of White students. In doing so, research agendas focus on advancement and gains in communities of color (Gutiérrez, 2008). Milner (2020) suggests:

> While on one hand it is necessary to hold educators accountable for providing optimal learning opportunities for students, on the other hand, our instructional practices need to be tailored for students in ways that honor them as diverse human beings by building their intellectual, social, psychological, and emotional muscles to succeed academically. (p. 4)

The direction of this study on TMCEJ is an effort to understand the potential for combining elements from inside and outside of the school, illuminating systematic racism and impacting what Milner (2020) posits as the opportunity gap. Moreover, a focus on the opportunity gap positions the educator to critically examine how systems and institutions maintaining the status quo complicate educational disparities (Milner, 2020). One such way to address the opportunity gap is to focus on critical math literacy that was first advanced by Giroux in 1983.

Gutstein (2006) considers two types of critical math literacy in education and applies them to mathematics content with implications for learners of color. Functional mathematical literacy focuses on basic math skills that support all members of society with competencies for basic mathematical communicating, reasoning, and problem-solving. Math education that focuses solely on functional literacy is problematic for members of historically underrepresented groups because it "leaves unexamined structural inequalities that perpetuate oppression" (Gutstein, 2006, p. 7). Critical mathematical literacy focuses on the learner's pursuit of relationships between ideas and explanations for thoughtful problems. A focus on instruction for critical math literacy that is embedded in a context applicable to students' lived experiences can help build student agency and positive mathematical identities (Gutstein, 2003). Teaching mathematics for social justice is one avenue to support critical mathematical literacy to address

the opportunity gap and move conversations away from the deficit model (Childs & Johnson, 2018; Viesca et al, 2013).

Teaching Mathematics for Social Justice

Theorists have long advocated for a social justice frame to position the achievement gap in math standardized test performance as the result of inequitable educational systems versus perpetuating the myth that differential achievement in math results from individual circumstances (Frankenstein, 1990). Teaching mathematics for social justice is such a frame and serves as the foundation for a TMCEJ initiative. Applying a social justice pedagogical lens to math instruction is not a new idea, and it has often been used interchangeably with terms rooted in the critical paradigm such as culturally responsive pedagogy (Ladson-Billings, 2009b) and critical pedagogy (Frankenstein, 1990; Freire, 1970/2005; Skovsmose, 2012). In addition, examples of social justice approaches are present in math movements in education including ethnomathematics, critical mathematics, and other traditions to empower people of color (Atweh, 2012). For the purposes of this study, teaching math for social justice is defined as supporting students in using mathematics to: a) critically examine unjust social, political and/or economic structures; and/or b) consider ways students can participate in transforming these same structures at the local, national, and/or global levels (North, 2006; Westheimer & Kahne, 2004).

Many advocates for teaching mathematics for social justice trace the roots of their thinking to Paulo Freire (1970), whose book, *Pedagogy of the Oppressed*, posited education as a tool of empowerment. Rooted in this theory, critical mathematics emerged as a tool for using mathematics to understand various socially constructed oppressions within social and political systems (Frankenstein, 1983). Since the 1990s, math organizations, such as the NCTM (1989), have been advocating for culturally relevant approaches to mathematics teaching to engage all

learners in accessing mathematics. Frankenstein (1998) advanced the notion of critical mathematical literacy to support learners in constructing social and political awareness through the use of mathematics and dialogue between learners and the instructor. This intentional exchange serves the purpose of minimizing power dynamics that exist between the teacher and students that can hinder learning.

According to Bartell (2013), math education should serve two purposes. It should provide students with access to the dominant mathematics curriculum necessary to demonstrate academic achievement in their current system. Moreover, students should be allowed to use the dominant math curriculum to expose and challenge societal structures that are obstacles to their success (Gutiérrez, 2013a; Gutstein, 2003; Martin, 2003). Teaching math for social justice addresses these two components. A social justice pedagogical approach embraces critical math literacy while pursuing systemic causes of injustices, supporting students in developing mathematical power for use towards emancipation from societal oppressions (Gutstein, 2006). A CRT lens helps identify benefits and opportunities in these studies on teaching math for social justice with implications for a TMCEJ initiative.

Benefits to Social Justice Education in Mathematics

Several studies have shown favorable outcomes in student growth measures as a result of teaching mathematics for social justice to support the achievement of historically marginalized groups. For example, some studies have shown: (a) students had positive outcomes from participating in a social justice educational experience (Bartell, 2013); (b) a social justice student-centered classroom showed significant gains on a pre- and post-test (Bowens & Warren, 2016); (c) through the use of questioning as an instructional tool, students were able to engage in math projects that were specifically created for them to understand their own realities (Gutstein,

2006); and (d) counter storytelling created a space for students to share their experiences with race and racism, increasing engagement in mathematics instruction (Berry, 2008).

First, Bartell (2013) demonstrated the value of social justice education in a study with eight secondary math teachers who voluntarily elected to enroll in a course on learning to teach mathematics for social justice. The qualitative study included debriefing sessions, written teacher reflections, lesson plan artifacts, final course papers, and pre- and post-seminar teacher interviews. One of the main findings from this work was that K-12 students could apply mathematics to examine social justice issues with success. This study also revealed that teaching mathematics for social justice positively impacted students' view of their educational community.

Cochran-Smith, Shakman, Jong, Terrell, Barnatt, and McQuillan (2009) conducted a qualitative study using interviews with 12 preservice teachers and their instructors that included making observations and examining artifacts. The study aimed to examine how students in a social justice preservice program understood and implemented social justice teaching. One of the key contributions from this study was that teachers held students to high standards, supporting the students' development of stronger thinking skills. Overall, the K-12 participants in this study had positive academic outcomes from participating in a social justice educational experience.

Second, a study by Bowens and Warren (2016) investigated the impact of a structured social justice mathematics intervention program on urban middle school students' math achievement. The mixed-method study presented pre- and post-test scores and three years of standardized tests of student participants, revealing significant mathematical gains. Interview data with program administrators showed teacher success with implementing mathematical discourse, engaging and challenging lessons with authentic questions, and other interactive

approaches to instruction. Therefore, the student-centered classroom supported students who traditionally did not have success in mathematics.

Third, evidence of the benefit of social justice education is further visible in the study by Gutstein (2006). The researcher conducted a semi-ethnographic practitioner-research project with a Mexican/Mexican American working-class community to identify three teaching mathematics goals for social justice. These goals supported students working for equity and social justice as "helping students develop sociopolitical consciousness, a sense of agency, and positive social and cultural identities" (p. 40). The goals emerged from students learning to use mathematics within the reality of their lived experiences. Through the use of questioning as an instructional tool, students were able to engage in math projects that were specifically created for them to examine and understand their own realities.

Fourth, Berry's (2008) work exemplified being explicit about race in studying African American males' experiences in middle school mathematics. The study demonstrated how counter storytelling created a space for students to share their experiences with race and racism. One of the key findings from this study was the importance of centering African American males' voices and experiences to combat the practices and policies that are harmful to this particular group. Other findings included the value of increasing earlier schooling experiences for students and the influence of educators' perceptions towards students' success. A social justice frame for math in the K-12 educational environment presented the opportunity for centering the voices of historically underrepresented groups that is particularly beneficial to students of color (Gutstein, 2003; Harper, 2019).

A study by Panthi, Luitel, and Belbase (2018) explored math teachers' perceptions of social justice in mathematics classrooms. Through one-on-one, in-depth interviews with three

secondary mathematics teachers selected from a convenience sample, Panthi et al. (2018) conducted a thematic analysis and revealed five central themes that describe math teachers' perceptions of social justice in the classroom: equality, equity, fairness, social process, and caring students. The five themes conveyed math teachers' identification of the benefit in social justice education with three themes--equality, equity, and fairness--having broader policy implications (e.g., access to resources and societal treatment of students). Howard (2003) advances culturally relevant pedagogy as the means of supporting students' needs from culturally diverse locations and suggests teachers engage in critical reflection of their personal views of their identities and their students' identities to support the success of this practice. These practices are enmeshed in the research studies above and support an environment conducive to social justice exchanges between teachers and students.

Finally, Moses (2001) provided an example of cultural modeling through what has become known as the Algebra Project. This project aimed at having students complete the high school math sequence that prepared them to access college level math. Not only did the project generate student excitement through the use of advanced mathematical representations present within students lived experiences, but it boosted their self-esteem. For example, the number line could be connected to students use of the urban transit system; thus supporting students' conceptualization of algebraic representations. The Algebra Project and the other representations demonstrate positive outcomes from embedding students lived experiences in math instruction.

Limitations When Teaching Mathematics for Social Justice

Notwithstanding the positive impacts of teaching mathematics for social justice, researchers have also identified limitations with the practice. First, classroom educators introducing the social justice curriculum in the mathematics classroom may not follow through

with pedagogical practices that involve conversations about race. In such cases, students struggle to transition from examining an existing social problem to applying a critical lens to broader social justice issues. For example, Bartell (2013) investigated the relationship between mathematical goals and social justice goals and found while students successfully applied mathematics to social justice, there was little substantial evidence of students critically engaging in interpretation and responding to these issues. Esmonde (2014) cautions educators about the marginalization of people of color when opportunities to examine racism are not pursued. Social justice education must follow through with the discussion of racism to accomplish the desired outcome of a social justice curriculum. This limitation has implications for professional development for teachers who will integrate mathematics curriculum into a climate and environmental justice framework.

A second limitation is the need to strengthen the teacher's ability to balance social justice pedagogy with mathematics curriculum during math instruction. A study by Brantlinger (2013) describes experiences of teaching students in a nine-week high school math remediation course. One of the challenges described is the risk of social-political themes removing time from dominant math curriculum. In other words, participants had difficulty navigating the mathematics instruction and social justice issues in classroom instruction. Such a view is also supported by Nicol, Bragg, Radzimski, Yaro, Chen, and Amoah (2019), who created math problems for social justice in STEM. Collecting data with 12 participants, the team utilized dialogue, interviews, and examined problem development to understand participants' navigation between mathematics, social justice, and STEM. Participants also found difficulty integrating STEM fields with social justice applications, for two reasons. First, there was difficulty extending mathematics without a broad understanding of mathematical opportunities. Second,

participants who taught higher level mathematics had greater difficulty integrating social justice tasks because of the time constraints from the curriculum.

The key implications from these studies are that a social justice pedagogical approach to mathematics has the potential to support positive student outcomes. There are also limitations that exist such as students transferring critical examinations of inequalities that exist in society and the challenge for teachers to bridge math content with the social justice topic. According to Wright (2016):

> Mathematics can serve as a powerful means for developing students' understanding of issues of social justice, and … students are likely to develop an understanding of both social justice issues and mathematical concepts when there is a meaningful link between the two. (p. 113-114)

Studies also demonstrate a benefit to the long-term implementation of a social justice curriculum focusing on one social justice issue (Bartell, 2013; Stocker, 2012). As such, the urgency of the climate crisis, drastic impact on historically underrepresented groups (Schlosberg & Collins, 2014; Shepherd & KC, 2015), real-world critical math application to communities of color, and potential for interdisciplinary connections support examining the potential to have a TMCEJ initiative.

Mathematics Embedded in a Climate and Environmental Justice Framework

Notwithstanding the importance of other social justice topics, research shows that focusing on one social justice topic can be beneficial to practicing social justice pedagogy (Bartell, 2013; Stocker, 2012). Not only is climate and environmental justice a relevant social justice topic, but it is broad enough to embed other justice issues as it impacts the most vulnerable communities within the U.S. (Black, 2016; Shelby & Kagawa, 2018). This study

builds on critical race traditions and the contributions of researchers and theorists who teach mathematics for social justice to examine applicable connections between climate and environmental justice and mathematics. This discussion will center on three areas: (1) an examination of climate and environmental injustice; (2) climate and environmental justice as grassroots movements; and (3) introducing climate and environmental justice into the mathematics classroom.

Climate and Environmental Injustice

Toxic industries, landfills, and brownfields within proximity of communities of color create products and services for human consumption and are the primary producers of greenhouse gases (GHG) that cause climate change in the earth's atmosphere (Shepherd & KC, 2015), thus the intersection of climate and environmental injustices. Carbon dioxide is the primary GHG that industries emit into the Earth's atmosphere, causing global warming in Earth's average temperature. The United Nations founded the Intergovernmental Panel of Climate Change (IPCC) in 1988 with the charge of providing updates on the important climate changes that are resulting from global warming (Roser & Seidel, 2016). The IPCC has warned of the need to immediately reduce greenhouse gas production to keep the warming temperature below two degrees Celsius (IPCC, 2014).

The impact of global warming, caused by the production of greenhouse gases, cause changes in the earth's climate such as extreme temperatures, droughts in some areas, and historic flooding in others because of glacier melting, creating visible impacts of changes in plant and animal ecosystems. However, one of the subtle impacts of climate change is the disproportionately negative impact of the crisis on Black, Latinx, and Indigenous populations

with unequal representation in all levels of decision-making processes (Kluttz & Walter, 2018). Climate injustices occur because the groups contributing to global warming the least are those who experience the most significant impact from the climate crisis. For example, the climate crisis exacerbates food scarcity and reduces access to healthy foods in communities of color. The disruption of the food supply causes food prices to spike in areas that already experience a food desert. Residents of low-income communities of color who are impacted by extreme weather conditions experience further victimization when attempting to receive disaster relief because they do not have the economic resources or social capital to ease the disaster's impacts.

History of Climate and Environmental Justice as a Grassroots Movement

There are three conceptualizations of climate justice as described by Schlosberg and Collins (2014): (a) elite organizations, non-governmental organizations (NGOs), focus on the policymakers and promote a voluntary, economical approach to meeting climate justice demands; (b) grassroots climate justice movements focus on supporting the most vulnerable communities who, in addition to the earth, are exploited by fossil fuel industries; and (c) academic theories that focus primarily on those responsible for the climate crisis correcting the issue for intergenerational justice (Shelby & Kagawa, 2018). Academic scholarship on climate justice primarily centers on intergenerational justice that is void of a critical race lens for examining the alarming impact of this crisis on the most vulnerable communities (Black, 2016; Shelby & Kagawa, 2018). Higher education and K-12 educators are not readily aware of this global crisis. Schlosberg and Collins (2014) propose that a reason for this is that participants in social movements do not often pursue scholarship as the means to clarify their positions. Another factor could be the intentional void of space as intellectual property for a climate justice conceptualization that centers on race. The absence of a focus on race in academic climate justice

scholarship has implications for what critical race theorists advance as colorblindness in the discipline of education (Ladson-Billings & Tate, 1995).

An essential goal of CRT is to illuminate relationships between "race and other axes of domination" (Parker & Lynn, 2002, p. 10). Researchers advocate for race-centered and diversity-focused curricula as essential components for students' academic and social success (Gutiérrez, 2008; Milner, 2020). TMCEJ builds on critical race traditions and the contributions of researchers and theorists who study teaching mathematics for social justice by identifying racism and classism at the roots of climate and environmental injustices. According to Gallay, Lupinacci, Sarmiento, Flanagan, and Lowenstein (2016), the privatization of public resources is at the origins of economic inequality that emerge from environmental justice. In the 19th century, public spaces for food production and animal grazing became private spaces that cut off community access to these natural resources. There was an increase in this privatization and land acquisition during the industrial revolution, as fossil fuels were the source of power for the newly emerging industry. The increase in elitism and privilege was the result of the privatization of public resources. Concurrently, there was the emergence of classism and environmental issues.

The historical privatization of public resources has an intersectional impact on communities of color. With a multi-generational history of enslavement and systemic racist practices such as redlining, African Americans continue to experience the violation of their human rights for the interest of an elite few. African, Latinx, and Indigenous Americans suffer the most from environmental injustices stemming from industries releasing toxins into the atmospheric, land, and hydraulic systems (Gallay et al., 2016). Research shows that Robert Bullard, considered the pioneer of the environmental injustice movement, and other proponents of environmental justice have worked to illuminate these injustices and their impact on

historically underrepresented groups (Schlosberg & Collins, 2014). It was the impact of Hurricane Katrina that was the beginning of the nationwide exposure to the experience of climate and environmental injustice.

Various movements, such as Black Lives Matters (BLM) and Me Too, address power issues in society, overlap with the tenets of social justice, and seek the fair distribution of social, environmental, and economic resources in society. Climate and environmental issues are emerging as an area of growth in critical race scholarship to the extent that they have become "front-burner issues" (Delgado & Stefancic, 2017). The disproportionate placement of environmentally toxic facilities in communities of color increases climate and environmental dangers and biohazards. Critical theorists consider this a type of internal colonialism, where corporate defenders argue that such communities are the best locations for their facilities as they bring jobs to impoverished areas (Delgado & Stefancic, 2017).

Consequently, there is the need to redefine and reframe the climate crisis (Hall, 2016) as a civil rights concern to understand how people of color and the economically disadvantaged are disproportionately targeted and affected by the pursuit of ownership and maintenance of economic prosperity for the wealthy. It is even advanced that the climate crisis is the "most urgent and deadly issue facing women, poor people, and communities of color today" (Hall, 2016, p. 122). Though physical location, socioeconomic characteristics, and other factors vary among impacted communities (Shepherd & KC, 2015), all students in such communities can personally relate to climate and environmental injustice and identify their form of advocacy for climate and environmental justice. For this reason, TMCEJ has the potential to be a powerful analytic tool for efficiently disclosing climate and environmental injustice and constructing paths towards climate and environmental justice. As a result, generic real-world mathematical

applications in the classroom, such as consumer math and the probabilities with decks of cards, are expanded to investigating injustices and critical math applications (Gutstein, 2006).

Introducing Climate Justice into the Math Classroom

Mathematics is a powerful tool for helping students develop an understanding of social justice issues, particularly when a connection is made between the two (Wright, 2016). This connection is made possible when the educational curriculum reflects the lived experiences of students from diverse backgrounds (Milner, 2020). Problematizing students' lived experiences as impacts from climate and environmental justice supports students in examining their realities that can prompt them to take transformative action to contribute to changing the world (Gutstein, 2006).

A TMCEJ initiative is two-fold and supports the representation and democratic participation of all students. First, this curriculum approach is an effort to engage students with a relevant and pressing social justice issue with significant implications for their future. Second, this approach can support student use of mathematics to understand, interpret, and participate in activism for climate and environmental justice. For example, Fisher (2015) conducted a qualitative study heavily drawn on life history research to understand how young climate activists conceptualize their commitment to climate activism. The findings included various life experiences contributing to activism, such as influences from family and friends, continuous exposure to social and environmental issues, and early life connections to nature. These experiences influenced student awareness of injustice, establishing personal commitment, and continuous ongoing reflection that influenced their current climate activism (Fisher, 2015). The study demonstrated how social issues are intimately connected to and have implications for addressing climate change.

Participants in the study by Fisher (2015) were not urban public-school students. However, there are implications for supporting students who do not have traditional environmental exposure. According to Howell and Allen (2019), "Environmental education specifically directed towards promoting engagement with climate change need not entail promoting outdoor experiences, nature connectedness, or biospheric values and motivations for action" (p. 827). Environmental and outdoor exposure are not needed because climate change is a social problem with environmental impacts. The authors further emphasized using caution when framing climate change education as environmental education because of the historical attachments to environmental movements being of interest to a small fraction of the population and excluding minorities and lower-income individuals (Howell & Allen, 2019). It is this consideration that reinforces the importance of aligning this research with the grassroots climate and environmental justice conceptualization. It also presents teachers' opportunity to engage students in constructing counter stories to write historically underrepresented groups in the narrative.

Evidence of a grassroots movement impacting local changes is visible in Portland, Oregon, where the community implements climate justice education in the social studies and science school curriculum. According to Bigelow (2020), teachers, students, parents, community members, and other stakeholders established the Climate Justice Resource Kit in Portland in 2014. Shortly thereafter in 2019, the Zinn Education Project launched a Teach Climate Justice Campaign to create a free online climate justice curriculum for K-12 teachers to promote climate justice education (Bigelow, 2020). In 2019, Portland Public School Board of Education hired the nation’s first Climate Change and Climate Justice Programs Manager to lead a number of initiatives, including a plan to address the deficits in the climate justice curriculum development

(Berg, 2021). Though this initiative is occurring within social studies and science contents, it has promise by reflecting one community's efforts to put climate in the center of the curriculum and teach it to confront structural-based inequalities.

Though climate change is a component of the science education curriculum, the Zinn Education Project demonstrates that climate justice is not limited to the science classroom. According to the project, climate justice advances four objectives: a) to probe the systemic causes of the climate issues; b) to center race and inequality and how practices that harm the environment disproportionately impact the poor and people of color; c) to aid in student understanding of activism as a source of identifying issues of importance and having a positive impact on society; and d) to focus on societal change to help students build analytical and critical thinking skills. These objectives can be significantly influential in the mathematics classroom where teachers, at times, deliver content in a vacuum without real-world experiences as frames of reference (Bartell, 2013). Framing core content in climate issues relevant to student experiences can help students develop academically and influence student awareness of concerns that impact their community.

TMCEJ for the Construction of Counter Stories

Students can construct counter stories to support the development of their critical race consciousness. Counter stories are particularly helpful in student awareness of climate and environmental injustices and are a form of analysis supported by critical race theorists in education (Parker & Lynn, 2002). The dominant narrative about climate change is about its impact on the earth and the animal inhabitants. This mainstream narrative often does not focus on members of the most vulnerable communities impacted by the climate crisis. A second narrative, often present in the media, is that historically underrepresented groups do not

participate in the struggle to stop global warming. The climate and environmental movements continue to be primarily led by middle-class White men and are not often in the interest of those most impacted by the crisis (Pezzullo & Sanders, 2007). Students who identify liberal assumptions that include the nonparticipation of people of color engage in constructing counter stories to challenge the mainstream claims that perpetuate racism (Harper, 2019, p. 303). Counter stories present students with opportunities to document their efforts to minimize the warming of the earth and protect their communities from the negative impacts of climate change. Therefore, students construct methods to use mathematics to support and develop agency in work towards climate and environmental justice and may have opportunity within a TMCEJ initiative.

TMCEJ as A Long-term Approach

Not only does research on teaching mathematics in social justice support an interdisciplinary approach, but it suggests a long-term approach is valuable. The climate crisis is intricate and manifests in different ways. It is not always easy to draw connections between the climate and environmental justice issue and mathematics. Gutstein (2003) found that students could not draw connections between social justice issues and math concepts upon implementing a social justice curriculum. However, after a two-year time frame, there was evidence of students connecting links between the concepts and social justice issues, demonstrating a social justice consciousness progression. Stocker (2012) found that an in-depth examination of a particular social justice issue that is particularly relevant to students' experiences is more beneficial than choosing multiple social justice issues.

Helping students develop interests in climate and environmental injustices supports rapid student engagement. Increasing students' interest in social justice issues can help support their navigation of the mathematical work developing supporting claims (Harper, 2019). Students'

ability to communicate results from mathematical analysis is evidence of their deep understanding of social injustices (Harper, 2019). There must be a careful selection in the topic and application of climate and environmental justice in order for the experience to be a success. Careful planning of the justice learning experience helps minimize superficial connections between social justice and math topics (Bartell, 2013; Gonzalez, 2009). Collaborative planning opportunities are one example of beneficial activities that can take place within professional development for math teachers.

The opportunity for teaching mathematics for social justice is that a focus on a particular type of social justice may be more beneficial for students (Bartell, 2013; Stocker, 2012). Rather than infusing different social issues into mathematics, infusing mathematics into one broader social issue opens the doors for students to make connections between the inequities that occur within this issue, streamlining the topic and making mathematical connections.

Professional Development for Math Teachers

This research proposes a district-wide effort to carefully plan and implement a professional development program for TMCEJ that continually evaluates practice by focusing on professional competence. School divisions engage in the constant professional development of their teachers because learning does not stop once teachers transition from their preservice experiences. Even policy efforts in mathematics demonstrate a continuous emphasis on teaching practices as essential for a students' success in mathematics (Bartell et al., 2017). Professional development, as a type of systemic support, is particularly helpful for teachers in urban public schools to move from a focus on student achievement deficits to a focus on the advancement and gains of students of color (Gutiérrez, 2008). A TMCEJ initiative has the potential to be a long-

term process that requires the appropriate context for social justice issues and intentional practices for learning, planning, and implementation.

A broader and long-term district level approach involves supporting teachers with concerns illuminated in the research such as difficulty translating social justice theories into classroom practices (Bartell, 2013; Esmonde, 2014; Gonzalez, 2009). District leaders would need to carefully craft professional development programs with lessons centered in real-world climate and environmental applications that can support teacher mathematical understanding (Guerra & Ann, 2016). This point is further supported by Wright (2016), who proposes that collaborative and sustained professional development can support teachers in developing self-agency and self-efficacy in modifying classroom practices. Alexander, Teymuroglu, and Yerger (2019) also found that multiple interactions are necessary to engage in productive critical conversations. This time between conversations allows the professional development designers to consider other foci that may emerge during the professional development session. Finally, Bartell (2013) suggested that a 15-week graduate course on teaching mathematics for social justice was not enough time to support teachers in developing their practice and that teachers can benefit from conversations around the meaning of teaching mathematics for social justice over an entire year. Research supports careful planning and the allotment of time to implement quality professional development (Alexander et al., 2019; Bartell, 2013; Wright, 2016), which can be of value to a TMCEJ initiative.

This review of professional development for TMCEJ summarizes common themes in the literature about teachers' preparation and the desired student outcomes when considering a TMCEJ initiative. The dominant themes include supporting math teachers in: (a) developing a critical consciousness; (b) strengthening their math content knowledge; (c) negotiating time

constraints; and (d) operating within a shared understanding of oppression and justice education. This section closes with an examination of an equitable framework advanced to support student learning in mathematics.

Developing a Critical Consciousness

Teachers will need to develop and continually examine a critical consciousness to actively participate in a TMCEJ initiative. Critical consciousness was theorized by Paulo Freire (1970/2005), a seminal theorist in the critical tradition who became known as the father of critical pedagogy. His work to liberate oppressed populations in Brazil originates with the premise that education was the tool for raising oppressed groups' critical consciousness. Specifically, members of oppressed groups should be aware of the systems of oppression and the impact of these systems on the community. The development of this critical consciousness, termed “conscientização,” is the path toward liberation and empowerment of the oppressed. To this end, engaging in a liberatory pedagogy means having a purposeful application that leads to changing circumstances. Freire's (1970/2005) work is central to liberatory pedagogy in social justice scholarship, and his research supports students' analysis of the oppression in their lives and the implications for their communities, one of the goals of TMCEJ.

Part of developing a critical consciousness is centering race and implicit and explicit biases in discussions about the injustices to historically marginalized groups because, as advanced by critical race theorists, not acknowledging racially based differences dismisses systematic racism (Delgado & Stefancic, 2017). A study by Jackson, Taylor, and Buchheister (2018) investigated prospective teacher reactions to vignettes of students of different races exhibiting disruptive behaviors during instruction. By centering race, the researchers explored the teachers' equity-centered approach, deficit view, or intersection of two reactions. The study's

findings demonstrated differences in responses based on the students' race and gender in the vignette. The researchers identified implications for the study that included the need for educators to have opportunities to bring awareness to their hidden biases that, if not addressed, can have a detrimental impact on marginalized populations. The study also called for future research in learning more about supporting teachers to implement pedagogical practices to support all students' unique needs.

Harper (2019) adds that the promotion of colorblindness fails to recognize the present state of racism. A study by Bonner (2011) demonstrated that teachers can have intentions on structuring caring and equitable classrooms, yet still hold and advance generalities about the value that African Americans place on education. Such beliefs perpetuate harmful stereotypes and work against the purpose of a TMCEJ initiative. In the study by Gonzalez (2009), some teachers of color expressed beliefs of meritocracy and deficit views of their students even when considering the environment where students were receiving their education. Studies show that the deficit view can be held towards their racial groups by students and teachers of color (Picower, 2012). Darling-Hammond, Chung, and Frelow (2002) emphasized the importance of teachers understanding their students "in non-stereotypical ways while acknowledging and comprehending the ways in which culture and context influence their lives and learning" (p. 209). Therefore, a TMCEJ initiative challenges racial neutrality claims and centers on the disproportionate impact of climate and environmental injustices on African, Latinx, and Indigenous Americans.

In a semi-ethnographic practitioner-research project, Gutstein (2003) demonstrated the importance of an evolving critical consciousness for resolving the tensions between math and social justice. Establishing connectivity between dominant math curriculum and social justice

pedagogy requires teachers to invest upfront energies in preparing to support students in critically applying mathematics to real-world experiences. In order to do so, teachers of all races and ethnicities need to be willing to allow their critical race consciousness to evolve over time. Research shows that teacher's development of critical race consciousness is complex (McDonough, 2009). Waldron et al. (2019) conducted an exploratory study using a thematic analysis of interviews and focus groups to understand educators' views on climate justice and climate change education. Eight semi-structured interviews and seven focus groups were conducted to determine participants' conceptions of climate change and climate change education. Their study showed that participants held different conceptions of climate change. Education specialists viewed climate change as a human rights issue, while preservice and inservice teachers primarily viewed climate change in physical terms. However, members of neither group extended the justice agenda to the impact on historically underrepresented groups. This finding demonstrates the importance of professional development supporting teachers in having a critical consciousness of climate change and its impact on historically underrepresented groups. There should also be measures in place to support a consistent conceptualization of climate and environmental injustice and climate and environmental justice. Centering climate and environmental injustices in mathematics education means critically examining the educational system and complexities of the social construction of race (Brown-Jeffy & Cooper, 2011).

A study by Battey and Leyva (2018) suggested implicit racial attitudes contributed to the production of disparities in math education. Through making a theoretical case, the authors drew on work in mathematical literature to suggest measuring “implicit racial attitudes pre-post or at intervals during the PD work, to see if the focus on challenging deficit narratives produced a

change in teachers' implicit racial attitudes" (p. 33). In a similar context, Alexander et al. (2019) proposed critical conversations as a method to support teachers in developing a critical consciousness. The researchers explore the use of critical conversations in a professional development workshop style setting to engage mathematics faculty from across the U.S. in designing conversations about teaching mathematics for social justice. They defined critical conversations as cooperative learning strategies to "identify, explore, and respond to various interests and issues situated across differing values and beliefs" (p. 396). The authors advanced a process for critical conversations that is useful for developing a framework for community practice. The framework includes exploring implications and content connections, framing and reflecting on the critical conversation, and identifying barriers related to the goals of implementation. Critical conversations are useful in developing a community of practice where teachers can exchange knowledge and examine the tensions that emerge when examining social injustices. These conversations can also help teachers identify barriers to implementation and receive support from their colleagues by addressing these barriers. This framework can support an interdisciplinary effort to teach other content for social justice.

Another example is demonstrated by Wright (2016), who adopted a participatory action research methodology to study a social justice research group of five first-year teachers. The investigation on teacher collaboration to teach mathematics for social justice identifies three implications for math teachers' constructing a social justice lens. First, the facilitator of professional development is an important aspect of teachers critically examining their practice. Second, there is a benefit to teachers engaging with social justice research to support them in critically examining their practice and developing a better understanding of the structural causes of inequality. Third, findings from the study demonstrate that many math teachers share a

concern for social justice issues, which is promising when considering implementing a TMCEJ framework.

Teachers' development of a critical consciousness helps support student conversations about race and racism. Lac (2017) conducted an action research project to study the development of a critical race pedagogy curriculum for students and the challenges that emerged during the transition from theory to practice. A key finding was the difficulty in teaching and talking to students about race and racism. There were few models of this successful dialogue, and the researcher felt that scholarship could benefit from an increase in examples. Another key implication is the importance of teachers moving conversations from acknowledging that racism exists to examining the root causes of institutionalized racism. A specific proposal was advanced for school districts to support educational professionals in having candid conversations about race and racism. While this proposal does not account for questions that may organically emerge from the lesson itself, it does help prepare teachers for essential questions or conversations that may emerge.

These studies demonstrate the need for ongoing professional development to support teachers in the process of developing and growing a critical consciousness. Professional development that centers building teachers' critical consciousness may help teachers when responding to a variety of student replies that may emerge when centering race and racism in classroom discussions. Research shows that many teachers and students come from different socioeconomic and cultural experiences, resulting in conflicting views of teacher authority and appropriate student behaviors (Bonner, 2011). Quality professional development can help mitigate such conflicts where race is central to the content instruction and pedagogical approach.

Math Content Knowledge

The literature on teaching math for social justice suggests the need for professional development to support teachers in strengthening their application of math content to the social justice topic (Bartell, 2013; Brown & Brown, 2011). Too often, high-stakes testing pressure manifests as teachers using rote learning strategies that do not connect the content with students' experiences (Brown & Brown, 2011). According to Simic-Muller (2019), creating a curriculum built on real-world data is time-consuming, and some topics may not apply to real-world issues. Furthermore, there may not be enough focus on math itself or students may believe math should be separated from their lived experiences based on their conditioning from the lack of real-world examples infused in mathematics instruction. For example, a qualitative study by Raygoza (2020) pursued an understanding of a diverse group of teachers' practices with teaching mathematics for social justice and found a lack of curricular examples and time to integrate social justice themes in instructional delivery. Bartell (2013) also identified the need to support teachers in selecting appropriate mathematical data to teach mathematics for social justice. Embedding math content in professional development can support teachers by engaging in data-driven professional development that prepares them for the classroom experience. Questions for consideration include what type of mathematics can support the critical examination of a social justice issue and why these data support this conclusion. It is also helpful for teachers to provide examples of data that would support a particular argument about social injustice.

Lesson plan creation, content building, and maintenance at the district level can support teachers with balancing the three educational domains. Embedding mathematics in a climate and environmental justice frame at the broader level helps mitigate the challenges that emerge to support student access to grade-level mathematical content (Harper, 2019). Implications from a

case study on teaching for social justice show that integrating social justice content into the mandated curriculum can support teachers in meeting their administrative expectations and their commitment to social justice pedagogy (Agarwal, 2011). Customization also includes supporting teachers in selecting appropriate data that align with their goals and engaging in data-driven professional development experiences. Gutstein (2006) found problem-posing questions were useful for students and may have implications for supporting teachers. These experiences for teachers could include the identification of appropriate data and posing critical questions. There is also the suggestion for scaffolding opportunities to restructure and reshape the existing curriculum to design lesson plans that integrate marginalized knowledge (Agarwal, 2011).

Jacobs, Franke, Carpenter, Levi, and Battey (2007) conducted a study on professional development with 89 teachers from urban schools that focused on algebraic reasoning. An important outcome of this research, relevant to this study, are the following recommendations for professional development content to support favorable student and teacher outcomes. First, a relational thinking approach supports the connection of the work and concept across grade levels and is foundational for mathematical understanding, such as the equal sign. Second, ensure the concept is accessible to elementary-age students. Third, participatory and ongoing professional development supports teachers in "learning through participation in practice" (p. 284). Fourth, provide teachers with support and an entry point that builds the comfort of different levels, such as the equal sign and cue cards, to support teacher's execution of these conversations.

Teachers can support student connections by having certain lesson components accessible and available for students, such as previously collected data. Teachers' ability to maintain theme-centered math in a climate and environmental justice frame supports students in making continuous connections between mathematical concepts. With careful planning, supports can be

in place to move teachers to the specific application of math content related to social justice. For example, TMCEJ curriculum designers can reference the NCTM Standards for Mathematical Practice (SMP) (2010) for proposed mathematical practices to support students in accessing math content. The above examples advocate for professional development to support teachers' content knowledge to build their capacity to teach mathematics for social justice. Consequently, there is value in professional development programs providing teachers with support in the topics being addressed as they relate to students' particular communities (Agarwal, 2011; Jacobs et al., 2007).

Navigating Content Knowledge, Liberatory Pedagogy, and Professional Responsibility

A third theme in the literature is the importance of professional development for TMCEJ to consider time constraints and cognitive efforts that result from integrating social justice issues and mathematics. The impetus behind the administrative tasks can determine how teachers perceive the tasks. For example, assessment and accountability standards drive administrative tasks such as extensive student testing that can detract from instructional time and the teacher's ability to engage in liberatory pedagogies (Gutstein, 2006). However, there may be potential for embedding supports for approaching administrative tasks that can help frame this navigation in a positive light.

Equitable structures are helpful, considering "balancing teacher course assignments can help to broaden their vertical knowledge of curriculum, reduce new teacher burnout, foster collaborative learning communities that include experienced teachers and more" (Bush, 2019, p. 292). In a case study with a first-year social studies teacher, Agarwal (2011) described challenges with teaching social justice and accountability in the urban environment. The year-long multi-case study included semi-structured interviews and formal observations to translate the teachers' ideas into practice. Findings showed that the participants struggled to find a balance

between content instruction and social justice pedagogy. Furthermore, when there were opportunities to integrate social justice into the content, social justice content became an extension of the lesson. The study also showed that the participants felt the need to choose content over social justice pedagogy in certain situations. For example, a focus on the lesson content took precedence over integrating a social justice frame even when social justice focused on the participant's formal observation. One significant implication from this study is the value of integrating social justice content into the dominant curriculum to support teachers in meeting administrative demands.

Second, tensions arise in teachers' ability to navigate the curriculum requirements and teach social justice content. Bartell (2013) conducted a study with eight secondary math teachers to describe teachers' work when learning to teach math for social justice. The study's key findings revealed that teachers had difficulty negotiating the math content and social justice goals and often viewed them as dichotomous. The planning and the implementation of the lesson plan mirrored these patterns as the math content was discussed and presented at the beginning of the lesson, and the social justice goals emerged towards the end. Implications include supporting teachers in embracing social justice education as a long-term process embedded in instructional practice.

Third, liberatory education should not occur at the expense of knowledge in respective disciplines (Ladson-Billings, 2009b). Time limitations place students at risk of instructional decisions that can impact student exposure to the traditional math curriculum. This challenge often results in compromises in instructional decisions that resulted from time constraints. The compromise is even more critical when it is at the expense of students accessing the traditional mathematical curriculum necessary to progress in their grade-level content. Students must

receive instruction on the mathematical standards required for them to demonstrate growth in meeting those mathematical standards. More importantly, an understanding of the mathematics curriculum is vital for students' mobility into upper-level mathematics, an area that is often inaccessible to students of color. This limitation can be minimized by efficient theory and practice that move against the dichotomous approach to social justice education and integrate the pedagogy into the core content.

A fourth example is a qualitative study by Raygoza (2020) that presented an understanding of a diverse group of teachers' practices with teaching mathematics for social justice. A key finding was that high-stakes testing increased assessment and reduced the ability to teach and have autonomy in integrating a social justice curriculum. This study suggests the need to support teachers in navigating the educational domains of dominant math curriculum, social justice pedagogy, and administrative responsibilities.

Finally, Aguirre and Zavala (2013) presented a lesson analysis tool to support educators in making culturally responsive mathematics explicit in the classroom and for use in lesson planning. Data from a culturally responsive mathematics professional development informed the design of the tool for the purpose of supporting math teachers in developing pedagogical content knowledge for the diverse classroom environment and implementing it into daily instructional practices. Four components embedded in the lesson analysis tool were mathematical thinking, language, culture, and social justice. According to the researchers, this tool enabled teachers to engage in a critical analysis and critique of mathematics lessons.

A counterexample of navigating the dichotomy of math curriculum and social justice pedagogy is presented in a study by Cochran-Smith et al. (2009). The researchers found that the examples of classroom practices of 12 preservice teachers demonstrated their ability to center

students' content learning and encourage students to think critically about the content knowledge put forth and their life experiences. This finding is important considering preservice teachers do not have the pressure of high-stakes testing of inservice teachers. The implication is that the right supports can be beneficial in to supporting all teachers in navigating the three educational domains.

Common Conceptualizations

Professional development for TMCEJ must align conceptualizations of various terms. A finding from Alexander et al. (2019) has implications for navigating the dominant math content and social justice pedagogical domains. The researchers found that mathematical interpretations of injustice may differ among teachers. Participants had different understandings of the complex history of race and injustice in society. Differing definitions can cause a barrier to implementing a social justice pedagogy with consistency. Bartell (2013) found that the ability to engage with readings and sample lessons about teaching mathematics for social justice helped teachers develop and maintain functional definitions of the practice. To this end, critical conversations are useful in developing a community of practice where teachers can exchange knowledge and examine the tensions that emerge when examining social injustices. These conversations can also help teachers identify barriers to implementation and receive support from their colleagues by addressing these barriers.

Bartell et al. (2017) demonstrated a standardized math curriculum without tending to equity reinforces existing inequities. Therefore, the commentary presented a framework of core equitable teaching practices that work collaboratively with the Common Core State Standards for Mathematics (CCSSM) Standards for Mathematical Practice (SMP). The SMP is nine methods that students should be able to successfully demonstrate in the K-12 math classrooms. The

framework exists to support teachers to provide equitable opportunities for students as they implement the components of the SMP. The strategies include: (1) drawing on students' funds of knowledge; (2) establishing classroom norms for participation; (3) positioning students as capable; (4) monitoring how students position each other; (5) attending explicitly to race and culture; (6) recognizing multiple forms of discourse and language as a resource; (7) pressing for academic success; (8) attending to students' mathematical thinking; and (9) supporting the development of a sociopolitical disposition. It is not a requirement for every math lesson to incorporate all nine SMPs. Students can engage in multiple math practices when they work through a task.

In sum, the key implications from these studies are as follows: (1) teachers must perceive social justice and the dominant curriculum as a unified versus dichotomous approach to support the efficient negotiation of these two instructional domains; and (2) there must be shared definitions of key concepts when implementing a system-wide instructional approach. For example, professional development should include content on the history of oppression and social constructs embedded in society. Furthermore, there should be a clear understanding of the meaning of social justice and examples of the application to mathematics.

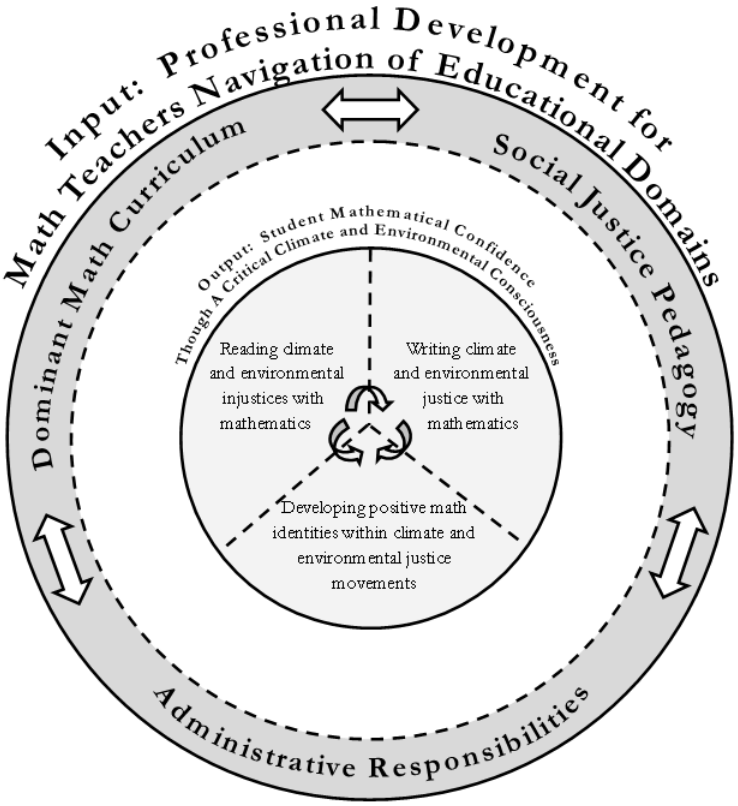
It is not uncommon to hear about teacher burnout in the K-12 profession, especially in the critical shortage area of teaching mathematics. However, Milner (2020) advances that both teachers and students can gain greater autonomy and freedom when they have the flexibility of adopting a critical stance towards school mathematics. Teachers should not have to choose between addressing justice and mathematics with their students. With careful planning, student engagement will occur simultaneously.

Conceptual Framework

A conceptual framework is presented for this study on TMCEJ that supported the development of the research questions and serves as a guide for the research study (Ravitch & Riggan, 2017). Researchers use this tool to present a graphical or written product that provides an explanation of the primary concepts or key factors to examine the presumed relationship between them (Miles & Huberman, 1994). Based on the review of the above literature, a conceptual framework is presented for this study through which TMCEJ was explored. Three teacher input constructs outline the perimeter of the conceptual framework. Three student output constructs represent the interior area of the conceptual framework. Figure 1 represents the conceptual framework for this study.

Figure 1

Conceptual Model



This conceptual framework synthesized the key concepts in the literature to inform and contextualize this study. Math leaders navigate three key domains to TMCEJ (RQ1 and RQ2): the dominant math curriculum, social justice pedagogy, and administrative responsibilities. The navigation of these domains (RQ3) demonstrates the potential influence of a TMCEJ initiative on the academic and critical development of students when math content is embedded in a justice- and equality-centered approach: (1) reading climate and environmental injustices with mathematics; (2) writing climate and environmental justice with mathematics; and (3) developing positive identities towards their use of math within climate and environmental justice movements. The conceptual framework is situated within a CRT lens, as race is often considered a major construct when examining issues of student performance in the educational system. This is not to suggest that other social constructs are not a factor. CRT allows for an intersectional approach (Ladson-Billings, 2013) and provides space for considering climate and environmental injustice that examines unequal racial, class, and other constructs that impact marginalized populations.

Teacher Navigation of Three Educational Domains to TMCEJ

This literature review points to important considerations for developing professional development that supports a TMCEJ initiative. Though literature on TMCEJ is sparse, teachers need to develop a critical climate and environmental consciousness. A more in-depth examination of climate injustices supports teachers' dominant math content and social justice pedagogy. The administrative responsibilities domain is supported when tasks are intentional and connect with the dominant math curriculum and social justice pedagogy.

The inservice teacher's navigation of the dominant math curriculum, social justice pedagogy, and administrative responsibilities provide valuable insight for professional practice. Bartell (2013) conducted a study on teachers' creation of mathematical tasks focusing on social justice, showing “that early tensions arose around balancing these goals, that teachers focused more attention on the social justice component, and that the instantiation of these goals in practice proved difficult” (p. 129). Equitable structures are helpful considering achieving balance in assignments can support opportunities for building curriculum knowledge, reducing teacher fatigue, and increase collaboration opportunities (Bush, 2019). For this reason, there is an opportunity in the research to understand the strategies and approaches that highly qualified math teachers bring to the classroom environment. Math leaders have years of application in the educational environment and a broader perspective of district organizational needs that can help inform engagement in critical pedagogy. The navigation of the three educational domains for this study can impact the conditions conducive to supporting student development of mathematical confidence through a critical climate consciousness. Professional development has implications for supporting teachers in navigating these three educational domains. See Table 1 for the expansion of the teacher input component of the conceptual framework.

Table 1

Expansion of the Teacher Input Component in the Conceptual Framework

Math Teachers Navigation of Educational domains		
Concept	*Expansion*	*Impact on Instruction*
Dominant Math Curriculum	Students need to develop knowledge of the math curriculum	• A liberatory education does not excuse the need for a quality math education (Ladson-Billings, 2009a).

		• Teachers need to deliver grade-appropriate math content to students according to the specified goals of accountability (Harper, 2019).
Social Justice Pedagogy	Use of math as a tool for students to recognize and analyze social injustices in their lives	• Instructional strategies engage students by teaching them to identify and critique institutional and societal power structures within the content area (Gutiérrez, 2002; Gutstein, 2003).
Administrative Responsibilities	Examples include high-stakes testing pressures, following predetermined instructional pacing, writing lesson plans, performing data analysis, communicating with parents, attending community, school, and district meetings	• Teachers navigate the delivery of liberatory pedagogy with the professional obligations that accompany teaching. Some situations require one domain taking precedence over another. • Research shows that navigation is often between the domains of social justice pedagogy and the dominant math curriculum (Bartell, 2013).

The Student Impact of TMCEJ

Gutstein (2003) identifies the three goals for teaching for social justice as "helping students develop sociopolitical consciousness, a sense of agency, and positive social and cultural identities" (p. 40). Reading and writing the world with mathematics is primarily built upon the earlier theories of Freire (1970 at the time), Frankenstein (1983,1990, 1998), and Skovsmose (1994). These goals are found in social justice literature and therefore serve to inform the conceptual framework for this study on TMCEJ: (1) reading climate and environmental injustice with mathematics (student understanding); (2) writing climate and environmental justice with mathematics (student application and agency); and (3) developing positive identities within climate and environmental justice movements (student transformation).

First, TMCEJ has the goal of using mathematics to read climate and environmental injustices in their communities. Students can use mathematics to understand the climate and environmental injustice impacts on their local community and the world around them. In these situations, students would use mathematics to understand the differences in the impact of the climate crisis on different socially constructed groups. Furthermore, students would highlight the differences in available opportunities and resources among these groups' that create disproportionality in their ability to respond to the climate crisis. This application is representative of the process of students using mathematics to understand the experiences that are taking place in their communities while strengthening and building upon their mathematical knowledge (Bartell, 2013).

Second, TMCEJ has the goal of using mathematics to critique claims against climate and environmental injustices (application) and formulate action steps to promote climate and environmental justice (agency). Writing climate and environmental justice with mathematics

supports students with creating arguments for identifying and eradicating social injustices, one of the goals of CRT (Parker & Lynn, 2002). Writing climate and environmental justice includes the students' ability to use their developing mathematical lens to make informed decisions in everyday life (Atweh, 2012). This process empowers students to choose how they will mobilize to influence their communities' future construction.

Third, TMCEJ has the goal of supporting students in developing positive identities and perceptions of their communities (transformation). NCLB was the driving force behind increased student retention due to inadequate performance that helped foster negative perceptions of students and their communities (Bonner, 2011). To dismantle this narrative, students of color need to see themselves from strength-based positions (Milner, 2020) and create counter-narratives representing their experiences. Climate and environmental justice movements provide the context to support students' development of positive identities considering the rich history in grassroots movements that are not present in academic scholarship. See Table 2 for the Expansion of the Student Output Component of the Conceptual Framework.

Table 2

Expansion of the Student Output in the Conceptual Framework

The Development of Student Mathematical Power Though Critical Climate and Environmental Consciousness		
Concept	*Expansion*	*Teacher Actions*
Reading Climate and Environmental Injustice with Mathematics	Students apply mathematics to understand climate and environmental injustices	• Teachers pose questions that support students in understanding issues of climate and environmental injustices in their community.

	that occur in their communities and the world around them.	
Writing Climate and Environmental Justice with Mathematics	Students are developing mathematical power as they use math as a tool to critically analyze institutions and learn to become agents of climate and environmental justice. Students build their confidence in math and themselves as members of society who can make a difference and impact climate and environmental justice.	• Teachers support students in understanding, formulating, and creating critical questions that use math as a tool. • Teachers help students develop an understanding of power dynamics at work in a society that can influence climate and environmental justice. • Teachers support students in building their confidence and beliefs that they have the power to choose their method of advocacy for climate and environmental equity.
Developing Positive Identities Within Climate	Students use their history in the advocacy for climate and environmental justice to	• Teachers are open to drawing knowledge from students and members of the community.

and Environmental Justice Movements	develop positive social and cultural identities (transformation).	• Teachers use this information to help students develop positive identities.

Reading climate and environmental injustices and writing climate and environmental justice support students' ability to better understand society's complexities (Gutstein, 2006). The understanding and critical analysis of their experiences with climate and environmental justice have a powerful impact on their sociopolitical existence, considering the historical devaluation of their race. This impact supports student development of critical mathematical literacy and self-perception as mathematical thinkers. Successful application of mathematics in a climate and environmental justice frame supports students' ability to advocate for and become agents of change. CRT places value in the transformative action that leads to student agency (Graham et al., 2011). A focus on climate and environmental justice community movements in the classroom permits students to be engaged in positive narratives that contribute to improving their lives and make meaningful contributions to their communities (Milner, 2020). The math classroom can serve as a group for climate action with the potential for participation in larger movements (Fisher, 2015).

Conclusion

A critical race lens was applied to this study to help frame the contextualization of TMCEJ. Math reform efforts over the past sixty years demonstrate a continuous struggle for students of color to experience equitable mathematics education in the K-12 setting. Teaching mathematics for social justice is an approach that has supported the achievement of historically marginalized groups and may have greater impact if systemically centered in a specific justice

topic. Climate and environmental justice is a relevant social justice topic with significant impacts on communities of color and the economically disadvantaged. A TMCEJ framework may have positive implications for student educational outcomes by supporting the development of their ability to critically engage mathematics and societal transformation. Therefore, it is important to consider professional development limitations and opportunities for TMCEJ.

CHAPTER 3: METHODOLOGY

The purpose of this research was to explore math leaders' integration of social justice pedagogical practices and current perceptions about how to best support teachers in navigating the dominant math curriculum, social justice pedagogy, and administrative responsibilities. Exploring math leaders' perceptions of navigating these three educational domains helped contextualize professional development needs for teaching mathematics for climate and environmental justice (TMCEJ). The following research questions guided the study:

- RQ1 What stories do math leaders share about social justice practices in math classrooms?
- RQ2 In what ways, if any, do math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities?
- RQ3 What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice?

This chapter examines the methods for this basic qualitative exploratory study and begins with the detail of the research design (Merriam & Grenier, 2019). Descriptions of participants, researcher relationship, data collection methods, and data analysis methods are detailed. The chapter concludes with an examination of ethical considerations that occurred throughout the study.

Research Design

This study implemented a qualitative methodological approach to explore math leaders' perceptions of professional development needs for TMCEJ. Qualitative research allows an understanding of the meaning participants' have constructed (Merriam & Grenier, 2019) and the unique voices for identifying patterns in the research (Maxwell, 2013). Furthermore, this

methodology allows the researcher to modify the research design in response to changes that may occur during the study (Maxwell, 2013). This form of inquiry resulted in the data needed to produce information about math leaders' perceptions of TMCEJ to contribute to the field of mathematics education.

A quantitative methodological approach was not utilized for this study because the methodology primarily focuses on yes or no questions and measures of degree. As a more traditional methodology that approaches research from a deductive theory-building frame, researchers often use a quantitative approach with the goal of studying a phenomenon objectively (McMillan, 2016). Considering the exploratory nature of this study, the emphasis on math leaders' perceptions, and the critical race theoretical framework that aligns with a qualitative methodology, a quantitative study would not have been an appropriate research method for this study.

Given the limited research base in climate justice education and inservice teacher navigations on teaching math for social justice (Bartell, 2013), a basic qualitative study design was the most appropriate methodological design for exploring this phenomenon. A basic qualitative research design has the central characteristic of enabling the researcher to understand what a phenomenon means to those involved (Merriam & Tisdell, 2015). The foundation for this study was built on social justice research with preservice teachers (Bartell, 2013) and the limited understanding of inservice teachers' social justice practices to generate descriptive and interpretive data on how math leaders perceive their work towards the success of students of color in urban schools. This information informed implications for professional development for TMCEJ. This study focused on an exploration of math leaders' experiences with teaching

mathematics for social justice, their navigation of pedagogical practices and administrative expectations, and perceptions of TMCEJ.

Within a basic qualitative design, interviews often yield the most relevant information from participants (Merriam & Grenier, 2019). Semi-structured interviews were conducted with math leaders to capture their narratives and counter stories, important critical race methodologies that center race (Dixson & Rousseau, 2005). Counter stories were particularly valuable to this exploratory study because they disrupt the deficit approach and destructive stereotypes of communities of color and their perceptions towards education (Milner, 2020; Viesca et al., 2013). Data were analyzed to extract common themes to identify some implications for TMCEJ. Document analysis was used as an effective method to support data collected during the interview process because it helps 'minimize bias and establish credibility" when it is combined with other data sources, such as interviews (Bowen, 2009, p. 38).

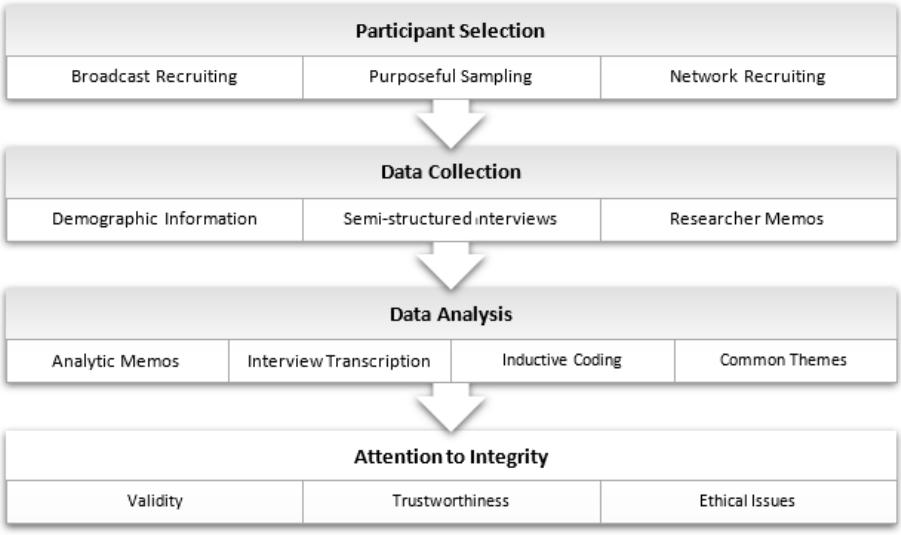
Critical Race Theory (CRT) was the theoretical framework used for this exploratory study to center the practices of math leaders that directly and indirectly impact students of color. This theoretical framework also supported centering race and racism to inform the potential for considering mathematics embedded in a climate and environmental justice frame. Critical race theorists use storytelling as one of the methodological tools for centering the voices and experiences of people of color (Parker & Lynn, 2002; Viesca et al., 2013). Storytelling is valuable in illustrating racial and social injustices and as a source of knowledge of the experiences of people of color (Childs & Johnson, 2018). The interview structure supported participants' narrative accounts to provide insight into experiences they had with teaching math for social justice to students of color. Data for a basic qualitative study "are collected through interviews, observations, or document analysis" (Merriam & Tisdell, 2015, p. 23).

Interviews created space for these descriptive stories that centered on race, a central tenet of the critical race theoretical framework (Graham et al., 2011). Interviews also provided the space for participants to share stories of classroom practices because critical race theorists show that storytelling can help countered the dominant deficit narrative of students of color (Milner, 2020; Childs & Johnson, 2018). Furthermore, interviews also provided a space for counter storytelling, described by critical race theories as a way for members of historically underrepresented groups to control the story that is communicated about their communities and lived experiences (Childs & Johnson, 2018; Harper, 2019).

Counter storytelling is the stories by individuals whose experiences are not often heard (Delgado & Stefancic, 2017), such as students in Title I schools and the math leaders who support them. It is a powerful methodological tool because it presents a space for these stories to expose realities and challenge dominant narratives that often represent those in power. This approach supported a better understanding of teaching math for social justice (Gutstein, 2003) that informed TMCEJ. Figure 2 presents an overview of the research.

Figure 2

Overview of Research Method



Setting and Participants

The setting and participants were intentionally selected to fill a research gap with an exploration of the social justice practices of math leaders in Title I schools and their perceptions of TMCEJ. Participants for this study were recruited through purposeful sampling. These strategies are outlined below.

Setting

Math leaders' work within Title I schools was the research setting for this exploratory study. The federal government identifies Title I schools to receive additional federal funds to assist with instructional and related resources based on the high percentage of students eligible for free and reduced lunch (Milner, 2020). Additional accountability measures are placed on staff in Title I schools to monitor the academic achievement of economically disadvantaged students (Bonner, 2011).

Former secondary middle school math teachers' experiences have been understudied, and their participation was beneficial to this study (Milner, 2020). The middle school environment supports the interdisciplinary approach considering students' first experience of the concept of climate change is in the sixth-grade science curriculum (mid-Atlantic State Education Department, 2010). Furthermore, middle school is the ideal environment to support early interdisciplinary connections to normalize conversations about race and racism as endemic in society (Harper, 2019). Finally, middle school is also when students increase their awareness of and develop an interest in career options.

Selection of Participants

Within social justice literature, a limited number of scholarly articles center on the voices of Title I math leaders who offer a unique viewpoint, having taught in the classroom before entering leadership positions. The foundation for this study was influenced, in part, by social justice research with preservice teachers (Bartell, 2013) and the limited understanding of inservice teachers' social justice practices to generate descriptive and interpretive data on how math leaders perceived their work towards the success of students of color in urban schools. Title I math leaders were familiar with the mandated administrative requirements and data collection that are unique to schools that receive federal funding and require a great deal of balance with other instructional responsibilities, especially when teaching math for social justice. Math leaders were unique because they had classroom experience, length of time in the field of education, comfort with the school context, significant experiences with pedagogical practices, and greater comfort implementing the curriculum without the stressors that new teachers often experience when transitioning from preservice to inservice (Garii & Appova, 2013). Being in leadership positions, this population could offer a unique perspective because they had insight into the decision-making that occurred in relationship to curriculum adoption at the district level that could best inform implications for professional development for TMCEJ. To this end, four criteria drove the identification of participants for this study. First, participants taught math for equity, access, and/or social justice. Second, participants were current or former math leaders. Third, participants had a minimum of one year of experience teaching math in the classroom setting. Fourth, participants had at least one year of teaching or leadership experience in a Title I middle school.

Purposeful selection was used for this exploratory research study because it supported the deliberate selection of participants. According to Maxwell (2013), this sample selection strategy allows the researcher to choose participants who can provide the best information relevant to the research goals that cannot be secured from other selection options. Researchers also use this selection method when there are only a limited number of persons, settings, or activities appropriate for the research study. There are other sampling procedures that the researcher could have selected for this study but opted not to. For example, criterion sampling would have supported the ability to select participants based on the identified characteristics (McMillan, 2016), but was not selected because it would restrict participants who may participate in teaching mathematics for social justice but not prescribe to the label. Maximum variation was another sampling method that was considered for this study to support a variety of perspectives from different districts in the mid-Atlantic state (Guba & Lincoln, 1986); however, access to the extensive number of participants required and the sufficient knowledge of their practices would have been a limitation to the timeline for the study.

Math leaders for this study were recruited through two different sources. Immediately upon approval from the Institutional Review Board (IRB), an initial recruitment email was distributed through two methods. First, math leaders who were participants of a mid-Atlantic state critical conversation group around equity in mathematics received an email from their host organization inviting them to participate in the study. Second, the researcher reached out to practitioners in their professional network who satisfied the selection criteria using their secured university email address. The recruiting emails stated how the person was identified, the purpose and procedures of the study, how to find out more information about the study, and a link that

interested individuals used to initiate contact by providing demographic information and their availability.

Research Relationship

The researcher made very intentional efforts to build rapport with participants to maximize the quality of the interviews. The researcher's position as a math leader helped gain other math leaders' trust. The researcher shared their part-time student and full-time math instructional coach status in hopes that participants would place greater weight on the practitioner's position in the educational system, rather than the research relationship. The researcher's dual roles as researcher and math educational leader were beneficial because it helped formulate probing questions that led to greater access to individual experiences. It also supported efforts to establish rapport with the study participants, who had similarities with the researcher and a sense of the shared meaning of experiences. The researcher's familiarity and work within this system posed a potential threat to validity. However, the benefits of the research outweighed the disadvantage of this work within this system because it presented the opportunity for the researcher to develop a quick rapport and an understanding of the contexts that emerged in the interview data. Furthermore, it supported the researchers' ability to drive probing questions to elicit specific information that helped arrive at the aim of the study. Another benefit of the researcher's knowledge in the field of study included an understanding of technical areas widely used and operated within this discipline. An effort to address this bias was through audiotaping and memo writing to be transparent about these influences.

Data Collection

Data was collected with five math leaders in a mid-Atlantic state. Originally, the researcher intended to collect data from six math leaders. While six participants were identified,

only five participants participated in the interview process. The participant who did not participate identified limited time as the reason they were unable to participate in the entire study. Multiple sources of data were collected for this exploratory study. Data triangulation is the use of different methods to support a single conclusion (Maxwell, 2013). Researchers use multiple data collection methods to reduce the risk of conclusions that reflect bias because they are collected from one data source. Data sources for this research study were collected through math-centered educational documents, semi-structured interviews with math leaders, and research memos. National level data included documents from the National Council of Teachers of Mathematics (NCTM) as it is the world's largest mathematics education organization. State level data, collected between January 2021 and March 2021, included publicly accessible documents from a mid-Atlantic state department of education. District level data included semi-structured interviews with the district and building level personnel and local policy documents such as the math curriculum guide.

Broadcast recruiting and professional networking techniques were used to identify math leaders across a mid-Atlantic state who were involved in math curriculum design and supporting teachers with curriculum implementation. Variation was desired and achieved by participants having work experience in a minimum of five different school districts in a mid-Atlantic state. A total of six participants was the target number for the study sample, five math leaders were available to participate in the interview process. Merriam (1995) further supports the trustworthiness of a study with five participants positing that “quite a bit can be learned from an N of 1” in studies that have established trustworthiness (p. 59). The researcher generated memos continuously through the data collection process to document the researchers' reflection of the data sources, including nonverbal behaviors observed during the interview process.

Data collection began at the receipt of the first demographic survey response and continued for a three-month period. Demographic data were collected via a Google Form that was generated using the researcher's university secured account (see Appendix A for the Eligibility / Demographic Information Survey). A follow-up email was generated to confirm the interview time with each participant and included a link to the climate and environmental injustice video series, *Freedom to Breathe* (PBS, 2019). Participants were asked to view the videos prior to the interview (see Appendix D for participants next steps). Non-demographic data were collected using semi-structured interviews because it can provide sufficient data to answer the research questions with flexibility for probing to capture respondents' stories (McMillan, 2016). Interviews with math leaders covered the following topics: (a) math leaders' stories about social justice practices in math classrooms; (b) math leaders' navigation of dominant math curriculum, social justice pedagogy, and administrative responsibilities; and (c) math leaders' perceptions of professional development needs to support TMCEJ.

The interview protocol was constructed to support participants in providing descriptive responses to interview questions (Merriam & Grenier, 2019). The interview themes did not have to be presented in a particular sequence, allowing the researcher to transition in a manner that did not require respondents to reorient themselves. The interview protocol included three open-ended questions representing the research questions for the study. Two of the three research questions supported participants in generating specific actions and events to retrieve previous experiences with teaching mathematics for social justice. Weiss (1994) emphasizes the value of this interview approach to ensure that questions are not prompting participants to provide generalizations or random opinions. Subsequent probes were prepared to support clarity and in-depth perceptions as follow-up to these questions. The flexibility in this instrumentation method allowed the

researcher to engage participants in conversations in an effort to increase their comfort and ability to reflect on their social justice experiences.

A vignette and a video series were included in the protocol to support participants in framing the phenomenon of climate and environmental justice. First, the study confirmation email included the link to *Freedom to Breathe*, a video series with five mini-videos on climate and environmental justice produced by the Public Broadcasting Service (PBS, 2019). Second, the researcher read a vignette to support participants in contextualizing TMCEJ during the interview (RQ3). The vignette represented a situation that helped define and provide an authentic local example of climate justice. Though the participants' responses were interpretive, this approach was selected to ease the transition and contextualize a discussion on TMCEJ.

Interviews ranged from 60 minutes to 120 minutes in length. Interview data were collected using a synchronous meeting platform with a unique meeting link that allowed the participant and the researcher to talk to and see each other. Participants were asked for permission to audio record the conversation to support the researcher in providing rich narrative descriptions of participants responses (Maxwell, 2013). The researcher conducted the interviews using the interview protocol as a guide (see Appendix B for Interview Protocol). The research questions that guided the study were: (a) What stories do math leaders share about social justice practices in math classrooms? (b) In what ways, if any, do math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities? and (c) What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice? Table 3 shows the alignment of interview questions with the research questions.

Table 3

Matrix of Interview Questions

RQ1: What are the stories that math leaders share about social justice practices in math classrooms?		
Interview Questions	*Probe*	*Purpose*
Can you tell me a time or two when a conversation about race surfaced in your classroom?	➢ Probe: What led to the integration of race? ➢ Probe: Could you walk me through how the lesson unfolded? ➢ Probe: How were the students responding?	These descriptive questions are for participants to reflect on their social justice experiences in the classroom. Participants are asked to share classroom practices used to center, draw student attention to, and/or initiate conversations about racial inequalities. Possible responses may provide information about whether or not teachers make intentional efforts to support students in having deeper understandings of the conditions in their lives resulting from their racial or ethnic background beyond their control using math content.
Have you ever found ways to integrate race into your math instruction?		

RQ2: In what ways, if any, do math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities?		
Interview Questions	*Probe*	*Purpose*
Please share a few things that flooded your mind as you listened to this vignette. (see Appendix B – Interview Protocol for the Vignette Balancing Professional Responsibilities)		These descriptive questions are for math leaders to reflect on their social justice experiences. Literature shows that teachers are often in positions where they have to choose between the time needed to carefully construct a math lesson centering on social

Can you tell me about a time when you, as a math leader, had to support a teacher with this balance?	➢ Probe: What led to this moment? ➢ Probe: Could you walk me through how you offered support? ➢ Probe: How was the teacher responding?	justice and delivering the dominant math curriculum that student's need to demonstrate mastery. Integrating social justice into the classroom experience is often set aside. District leaders who have taught mathematics for social justice are familiar with this predicament and may be able to propose different approaches to this balance now that they are the ones who hold teachers to performing their professional responsibilities.
What about a time when you, as a math leader, had to support an administrator with this balance?	➢ Probe: What led to this moment? ➢ Probe: Could you walk me through how you offered support? ➢ Probe: How was the administrator responding?	
Can you think about a story to share about a teacher effectively balancing teaching math content, engaging students with lessons related to their race/ethnicity, and administrative tasks such as pacing, assessments, and meeting Teacher Performance and Evaluation System goals?	➢ Probe: Please be as detailed as possible. Could you walk me through how the teacher effectively balanced these tasks? ➢ Probe: Was anyone else there when this was happening?	

RQ3: What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice?		
Interview Questions	*Probe*	*Purpose*
Please share your thoughts about the *Freedom to Breathe* videos.		Interpretive questions are posed for math leaders who are asked to provide their professional judgment/opinion on a) the feasibility of teaching math for climate and environmental
Please share your initial response to this vignette. (see Appendix B –		

Interview Protocol for the Vignette Teaching Math for Climate Justice). If you were in this situation, how would you respond?		justice and b) the professional development considerations to move a district of math teachers in this direction. Answers to this question will help frame the future implications of this study. Descriptive questions are also posed for math leaders to reflect on a time when they posed a social justice approach related to curriculum and instruction.
What would be necessary at the district level to support these teachers who want to make math content relevant to the students' community experiences?	➢ Probe: What professional development needs should be taken into consideration? ➢ Probe: What would be necessary for something like this to take place in your district?	
Tell me about a time when you, as a math leader, proposed a change or suggested instructional supports that centered around race.	➢ Probe: What led to this? ➢ Probe: Was anyone else involved in proposing or making decisions about your suggestion? ➢ Probe: How did they respond? ➢ Probe: How did you feel about the outcome?	

Data Analysis

According to Merriam and Grenier (2019), data analysis begins when data collection begins. For this exploratory study, data analysis involved identifying "recurring patterns or themes supported by the data from which they were derived" (Merriam & Tisdell, 2015, p. 25). Research memos were created within one hour after the interviews were conducted. Research memos are the researchers written reflections that are a valuable method of organizing salient themes that emerge from the interview and can help with the initial organization of the data (Maxwell, 2013). The researcher used data from the interviews and research memos to extract common themes and patterns that described the participants' experiences with teaching math for social justice and their perceptions of TMCEJ.

Audio recordings of the interviews were captured using a speech-to-text transcription application that automatically provided an interview transcript. The application provided a recording and synchronized speech recognition allowing the audio to be reviewed while examining transcription. The researcher played the audio recording of the transcript back, while reviewing the text-generated transcript for accuracy. The researcher corrected any incorrect transcripts so that the transcript matched the audio recording verbatim. Once the researcher ensured transcription was an exact replication of the audio, transcripts were anonymized by replacing actual participant names and locations with pseudonyms created by the researcher. Specifically, “mid-Atlantic state” served as a proxy for the state, “mid-Atlantic city” served as a proxy for the city's location, “leader #” served as a proxy for participants' names, and “they, them, or their” served as a proxy for the leaders’ gender pronouns. The anonymized online transcription-generated text was copied from the transcription application and pasted into a new document field in ATLAS.ti. for coding. Researchers use this software, known as computer-assisted qualitative data analysis software (CAQDAS), to assign codes, create concept maps, and segment the data sources (Maxell, 2013).

The researcher’s thoughts were captured in real-time using the ATLAS.ti comment field as they continued to emerge throughout the process. A research memo was created after the transcription process for each interview was complete. The research memo from the first interview was carefully read to provide a preview of the emic (data-driven) codes (Maxwell, 2013) that emerged from the interview data. The transcript was then read in full for the purpose of data immersion. Inductive coding was then performed to identify the specific properties within the data (Maxwell, 2013). Methods to engage in inductive coding included listening to the

recording of the interviews and making additional conceptual notes during the transcript verification process. This process was repeated for all five interviews.

After the third interview, an inductive process was used to identify patterns and relationships as subcategories that were established from the data (Merriam & Grenier, 2019). According to Maxwell (2013), this strategy is the process of reading the data and deriving coding categories from the data. Coding and categorizing were constantly reevaluated as the coding scheme was developed. This process took place through the last interview and continued as interviews were read again to check for evidence of any codes that may have emerged after these interviews. Several segments were assigned two or more codes for the purpose of associations once all codes were organized. Categories were then analyzed using an inductive thematic analysis to develop and interpret the themes. It was also at this time that emerging themes were aligned with research questions for specific insight.

Research memos, the researchers written reflections, were created at multiple stages of the data analysis process. Research memos allow the researcher to capture the progression of the researchers' conceptualization of the data during the development and implementation of the research study (Ravitch & Riggan, 2017). During the data collection phase, memos were created within one hour after each interview to support the researcher in engaging in a rudimentary analysis of the information shared by participants. Specifically, researcher memos were frequently created throughout the study to support the researchers' reflections in an effort to synthesize the data into themes in preparation for the data analysis (Miles, Huberman, & Saldaña, 2014). After each interview, publicly accessible documents were collected from the national, state, and local sources to support the researcher in establishing context for information provided by participants (Bowen, 2009).

Trustworthiness

This section describes the trustworthiness of the exploratory study. Several strategies were taken to increase the trustworthiness, or thoroughness, of this study. Each of these strategies are examined.

Validity is the degree to which the conclusions or interpretations of the study are correct (Maxwell, 2013). Two specific threats to the validity of a qualitative study are researcher bias and reactivity. Researcher bias was a threat to this qualitative study design because the researcher met the study definition of a math leader and supports teaching mathematics for social justice and TMCEJ. Therefore, the researcher engaged in the practice of reflexivity to examine critical reflections about biases, assumptions, and views that may have impacted the study (Creswell, 2014; Merriam & Tisdell, 2015). According to Maxwell (2013), memo writing supports critical self-reflection of possible influences of the researcher's specific values and expectations.

Furthermore, reactivity is the influence of the researcher on the participants in the study. Specifically, the role of the researcher, note-taking, and recording can influence the responses of participants. The researcher used creative interviewing to support a climate for mutual disclosure. Holstein and Gubrium (1997) advance this traditional image of interviewing as a set of techniques to transition the interview from a series of words to the authentic communication of emotions. The researcher was intentional about over-communicating to participants that their perceptions were of utmost importance to this study and that there was no correct or incorrect answer. The use of an audio recording program supported the researchers' ability to focus less on note-taking and more on a fluid interaction with the interviewee. While permission was requested at the beginning of the study, the audio recording device was placed in a location

where it would be a minimal distraction to participants. Furthermore, the researcher made every effort to have an awareness of participants' indicators of the interviewing partnership (Weiss, 1994). The researcher made efforts to recognize signals indicative of interview fatigue, discomfort, or boredom to ensure the participant felt comfortable in the interview setting.

Dependability is the ability to replicate the study with participants who have very similar characteristics to the study population. Detailed accounts of the sample selection, data collection, and data analysis for this study were provided. An interview protocol was also provided so that readers have access to the interview procedures and questions. These rich descriptions support the dependability of the study (Onwuegbuzie & Leech, 2007).

Memo writing and member checking were used to strengthen the trustworthiness of this exploratory study. The researcher engaged in extensive memo writing at various stages of the research process to ensure accuracy and minimize interpretative validity (Creswell, 2014), including initial contact with participants immediately following interviews, during the interview transcription process, after member checking, and other periods throughout the data collection and analysis process. Member checking, the process of returning information to the participants to verify the interpretation (Merriam & Tisdell, 2015), was the single most valuable way of minimizing the possibility of the researcher misinterpreting the participants' intended communication (Maxwell, 2013). To confirm participants' responses, an email was sent to study participants with a brief summary of the study conclusion by research question and a description of the interpretation of the quotes that might be used in the study. Participants were asked to review the quotes to make sure they reflected what they intended to say and that they perceived the organization as fair and reasonable. Participants were asked to respond with any corrections or modifications to their transcripts within 48 hours. No response from participants was

interpreted as verification of the transcript. All transcripts and interpretations were verified as correct by study participants.

Fourth, transferability is addressed to increase the rigor of this study. The results from this exploratory study are not intended for generalization because the goal was exploring insights into a particular phenomenon (Onwuegbuzie & Leech, 2007). Consequently, a purposive sampling scheme was selected for this study. With careful consideration, this study may be transferred to a very small population and setting for similar results.

Ethical Issues

This section addresses ethical issues pertaining to this exploratory study on professional development for TMCEJ. The study posed no serious ethical concerns to participants. However, due to the small number of participants, the researcher identified minimal risk of participants' concern about others in their place of employment learning about their participation in this study. Several measures were put in place to ensure confidentiality and anonymity so that only participants and the researcher knew identifiable information. First, each interview had a uniquely generated electronic meeting link that was only accessible to the researcher and the participant. The researcher conducted the interviews in a private office and participants had the option of participating in a space that was comfortable to them. Participants were informed of their right to terminate the virtual interview at any time and for any reason.

Second, though the interviews occurred on a virtual platform, there was not a video recording of the interviews--there were only audio recordings of the interviews. The researcher used Otter.ai, an online transcription application, to transcribe audio records. Only an electronic copy of the de-identified transcript was kept on the researcher’s secured computer.

Third, the researcher replaced all identifiable information in the transcript with pseudonyms. Because the study was exploratory in nature, it was not necessary for readers to be able to track which respondents made which statements. Therefore, readers were not provided with any identities, ages, pronouns, or locations to trace which respondents provided what responses. However, a spreadsheet that connected the identifier to the respondents' information was kept on the secured online storage platform for the researcher to use for the purpose of member checking.

Conclusion

Conducted within a qualitative framework, this study sought to illuminate the voices of math leaders to understand the social practices they engage in when teaching and supporting mathematics instruction in Title I middle schools and these implications for a TMCEJ initiative. Situated within a critical race theoretical framework, the research design, data collection, and data analysis were designed to ensure the voices of participants were accurately captured. Threats to validity, trustworthiness, and ethical issues were addressed in an effort to make this exploratory study as holistic as possible.

CHAPTER 4: FINDINGS

This chapter presents the findings from qualitative research into math leaders' former social justice pedagogical practices as classroom teachers and their perceptions on teaching mathematics for climate and environmental justice (TMCEJ). An important aspect of this undertaking was an exploration of how math leaders navigated the dominant math curriculum, social justice pedagogy, and administrative responsibilities. This research also sought to learn more about math leaders' perceptions of the intersection of climate change, social justice, and mathematics education as an opportunity for teachers to engage their students in critical conversations surrounding these topics that are often part of their students' lived experiences. The research questions that guided this study were as follows:

(a) What stories do math leaders share about social justice practices in math classrooms?

(b) In what ways, if any, do math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities? And

(c) What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice?

Qualitative Data Collection

A basic qualitative research design was applied to this study and had the central characteristic of enabling the researcher to explore math leaders' social justice pedagogical practices and perceptions of TMCEJ (Merriam & Tisdell, 2015). The goal of the study was to obtain insight into math leaders' perceptions of social justice pedagogy and TMCEJ. Purposeful

sampling was conducted to best ensure participants represented the characteristics of the study (McMillan, 2016). The sample comprised five math leaders who worked in five districts across a mid-Atlantic state. Math leaders were selected based on four criteria: (a) taught mathematics for equity, access, and/or social justice; (b) were current or former math leaders; (c) had a minimum of one-year experience teaching math in the classroom setting; and (d) had at least one year of teaching or leadership experience in a Title I middle school. The U.S. federal government designates a Title I school as a school that receives additional federal funds to assist with instructional and related resources based on the high percentage of students eligible for free and reduced lunch (U.S. Department of Education, 2018). For participants recruited for this study, teaching math for social justice was defined as supporting students in using mathematics to: a) critically examine unjust social, political, and/or economic structures; and/or b) consider ways they can participate in transforming these same structures at the local, national, and/or global levels. This definition was influenced by the work of North (2006) and Westheimer and Kahne (2004).

Participants for this study were recruited using purposeful sampling through two sources. First, participants were recruited via a one-time email of the study invitation through a mid-Atlantic state mathematics educational organization. Participants were also recruited through practitioners in the researchers' professional network who satisfied the criteria for study participation. A total of five participants opted to participate in semi-structured interviews.

Data Analysis

The first section of these findings provides a descriptive analysis of the demographics using frequency data. Identifiable information of participants was replaced with pseudonyms for

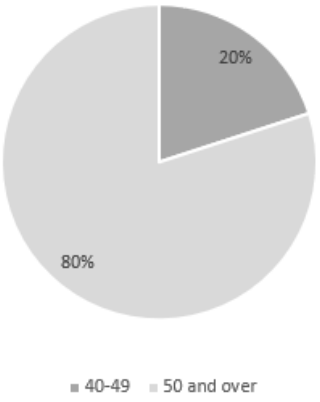
confidentiality and anonymity. Following the presentation of the demographic analysis, findings for each of the research questions are presented as themes that emerged from the data.

Participants

Five math leaders from across a mid-Atlantic state completed the online demographic survey. The instrument allowed for closed-ended responses to demographic questions. Four participants indicted their age was 50 years and above. One participant indicated their age as including or between 40 and 49. Figure 3 includes the age range of participants.

Figure 3

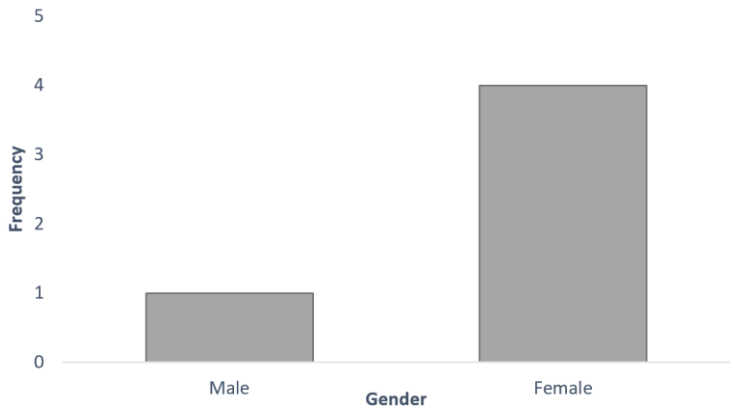
Participants Age Range



Participants indicated the gender they identified themselves as male, female, or other. The study included four female (80.0%) and one male (20.0%). Figure 4 includes the gender of participants.

Figure 4

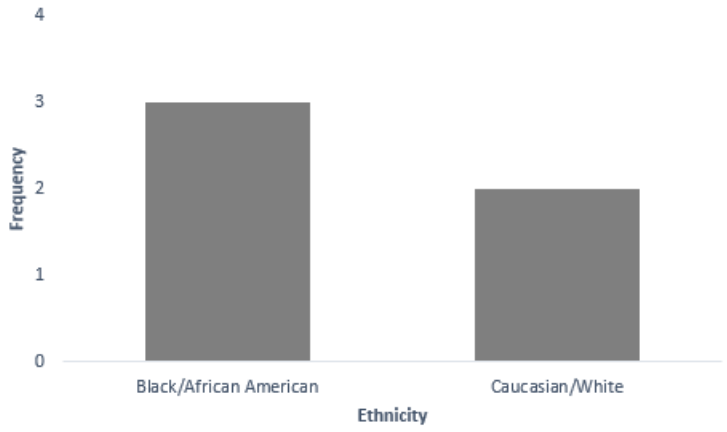
Participants Gender



Participants were asked to identify their ethnicity. Overall, 60% of the participating math leaders reported their racial-ethnic status as African American and 40% as Caucasian. Figure 5 represents participants ethnicity.

Figure 5

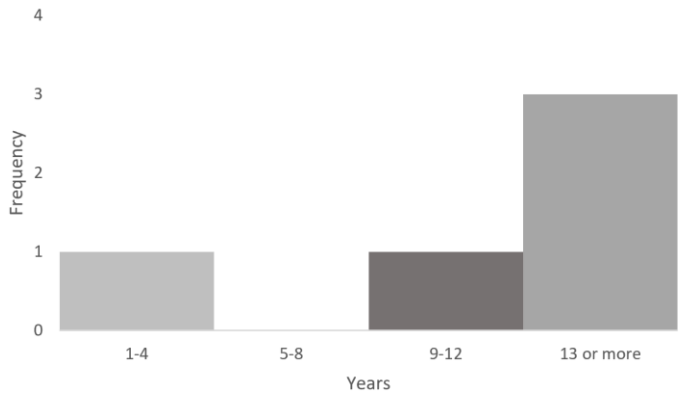
Participants Ethnicity



All five participants (100%) reported that they taught math at some point in their careers. Four participants (80%) reported that they were math teachers in a Title I middle school. Overall, 60% of participants taught grades P-5, 60% of participants taught grades 6-8, 40% of participants taught grades 9-12, and one participant did not teach math in the K-12 classroom. Overall, 20% of participants taught in the math classroom between one and three years, 20% of participants taught in the math classroom between 10 and 12 years, and 60% of participants taught in the math classroom for 13 or more years. Figure 6 includes the length of time participants provided instruction in the math classroom.

Figure 6

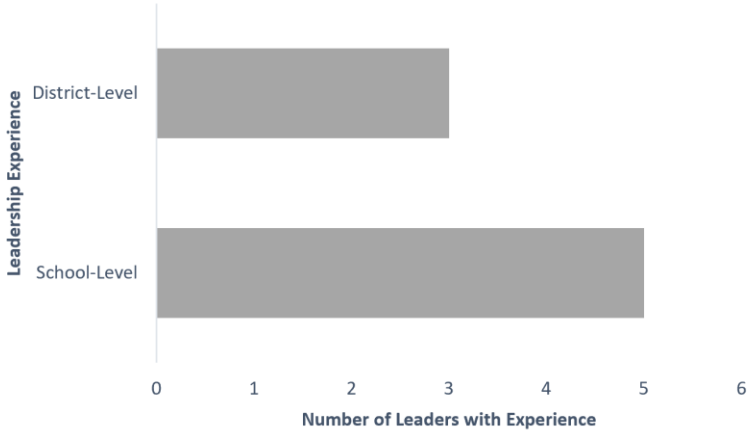
Participants Years of Instruction in the Math Classroom



All participants (100%) reported that they were math leaders in a Title I middle school. Furthermore, all participants (100%) reported they were a math leader at the school level, and three participants (60%) reported they were a math leader at the district level. Figure 7 includes the level of participants leadership experience.

Figure 7

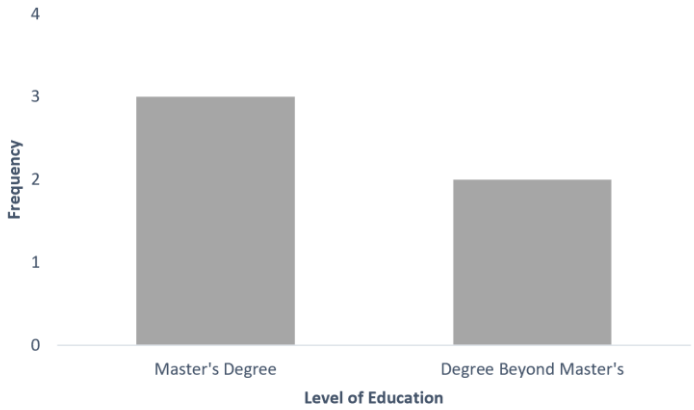
Level of Participants Leadership Experience



Participants were asked to indicate their educational experience. Three participants (60%) reported that they had attained a master's degree and two participants (40%) reported a degree beyond a master's degree. Figure 8 includes the highest level of education participants had achieved.

Figure 8

Participants Educational Experience



The constant revisiting of the interviews and the codes revealed themes that emerged in the data. These themes were derived from analytic categories that are grounded in the data (See Table 4). Findings from these themes are presented within the research questions that framed this study. The interview questions were compiled from the conceptual framework that was created based on the review of the literature. The data yielded a total of 128 discrete codes grounded in the data that were collected. The number was the reduction of 213 first-cycle codes that emerged as the researcher initially inductively and subsequently deductively examined the interview data through a constant comparative method (Ravitch & Riggan, 2017).

Table 4

Qualitative Thematic Results Organized by Research Question

Research Question	Themes	Sub-themes
What stories do math leaders share about social justice practices in math classrooms?	Generative Themed Topics	• Topics of Discussion • Student Readiness
	Relationship Building	• Classroom Culture • Student Advocacy
In what ways, if any, do math leaders navigate the dominant math curriculum, social justice	Balancing Educational Domains	• Teacher Retention • Assessment as Evidence • Empowered Educator • Administrative Supports

pedagogy, and administrative responsibilities?		
What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice?	Success Contingencies	• Current Social Justice Climate • Stakeholder Buy-in • National and State Equity Efforts • Curriculum Limitations • Hiring and Retention Practices
	Design and Delivery of Professional Development for TMCEJ	• Topics for Discussion • Curriculum Resources • Professional Development Supports • Implementation • Measures of Success

Presentation of Findings

Five central themes emerged from the analysis of the data that were used to answer the respective research questions: (1) generative themed topics; (2) relationship building; (3) balancing educational domains; (4) success contingencies; and (5) design and delivery of

professional development for a TMCEJ initiative. This chapter provides a summary of the findings from each theme.

Research Question 1

What stories do math leaders share about social justice practices in math classrooms?

This section describes math leaders' reflections on their social justice experiences when they taught in the classroom. Participants were asked to share classroom practices used to center, draw student attention to, and/or initiate conversations about racial inequalities. Participants' responses provided information about the intentionality of math leaders' efforts to support students in using math content to develop deeper understandings of the conditions in their lives resulting from their racial or ethnic background beyond their control. Two major themes that emerged from the data were generative themed topics and a relationship building. The following sections share the findings regarding these practices.

Generative Themed Topics

All participants in this study instructed math in the classroom environment and shared examples of classroom situations that they perceived as supporting students in examining unjust social structures in society. As participants elaborated on these stories, they presented accounts of experiences that were: (a) topics of discussion, (b) indicative of student readiness, and (c) lessons from practice. These sub-themes are examined below.

Topics of discussion. Math leaders shared rich stories of engaging students in social justice topics while exploring math content. All participants provided examples of discussions that focused on the constructs of race, class, and/or gender inequity in real-world examples. Some participants described efforts to impress upon their students the importance of their

performance in school in relation to future aspirations as adults. One leader shared that race "always came up just from the standpoint of, I would always tell my kids more is expected of you". This leader continued by telling students, "You have to be better than. We can't use excuses." Findings showed that African American leaders made reference to race in the classroom using indirect methods that often did not use the term "race," or in which ethnic group was not mentioned. Another leader shared that references to race often surfaced in conversations with students that centered on employment and wages. An example of the message shared highlights the need for students of color to understand that, "In order for you to get jobs and wages you have to do something. And therefore, you have to always be ten times better than some of your counterparts in order to be seen at a lower level."

In varying degrees, math leaders described conversations that centered on racial inequity in the educational institutional setting. These accounts represented social justice topics where race was the social construct that was the overt or covert focus of the conversation. A math leader shared an example of when students questioned their lived experiences that led to their awareness of the disproportionate number of Black students placed in special education classrooms. Similarly, reflecting a conversation that centered on race in education, another math leader shared a time when students discussed the number of Blacks who received tuition-free education at a top university in the country:

> We talked about being college-bound and part of that project was you had to actually show me how many kids, and we were looking at that particular time that's when NYU was going to have a no-fee tuition. How many of those students are actually Black? But we went into that and they had to actually talk about that. And then how many people

> really go to college and is it really needed for you to be successful. So those are the things we talked about but that was always around statistics.

The variety of ways that social constructs impact lived experiences were explored when students in another math leaders' class were introduced to the concept of gerrymandering. A rich discussion was described:

> Sometimes I would intentionally do things that dealt with mathematics or looking at when they wanted to go to different colleges and stuff and you look at data to say "this is the number of African Americans that go to this school. This is what gerrymandering means, and this is how even though we may be the dominant in a certain community, we can still lose because of the way that the districts are drawn." So just bringing those types of things into conversations just to make them aware of what's going on and just looking at the world around them.

An exploration of two mathematical concepts was conducted in one classroom through conversations about policing. Students were able to connect their lived experiences with law enforcement to learn about probability and measures of central tendencies. With no preplanned lesson to integrate this particular community connection, a lesson on probability involved students discussing the chance that they would walk down the street and see a police car on a daily basis. The mathematical concept of measures of central tendency was also an example of conversations in this classroom that the participant perceived as conversations that centered social justice, as in this example:

> We did talk about policing in the room like, on average, how many times do you see a cop car in your neighborhood? And it was kind of funny because of course, you know the

> Black kids like, “well that's one that just stay down [there] and they just park all the time.” Because they know it belongs to the village. They are just parked in the corner. I’m like “o-k.”

Further examples of social justice practices included bringing students’ culture and heritage into the classroom environment. Preceding mathematics instruction, one leader details how they learned about each other’s culture through students of various backgrounds sharing their culture with their peers. Students were empowered to select components of their heritage to share with the class. This math leader described this practice as impactful on building classroom community and supporting students in valuing their cultural contributions:

> Once you make sure that they all understood that you are really concerned about what is happening in their community and you're bringing things to them like having when it is Hispanic cultural month...This is your 15 minutes to teach us what you want us to know. I mean it was only four students but they had a month of activities to give to us. Same thing with African American students, and then we think about like, Okay, well what do the Whites do? ... And it did empower them.

Findings from this study showed evidence of conversations that centered on math and climate and environmental injustices. Of the math leaders, some provide one or more stories of social justice practices as classroom teachers that centered topics within climate and environmental justice. One leader shared:

> Many of the low socioeconomic groups live where there's a lot of pollution and environmental racism, including where they live. So you look at [city in mid-Atlantic state], there’s [fossil fuel company] and then smell down there. And you know that's

> something that was important for me because where I grew up, and my [family member] was in the [fossil fuel industry] and so that was like the same thing. Grow up and it's like all this environmental pollution we're ingesting. And so that was I think the biggest thing. Like, “Wow! Look here at [city] and look who lives near the pollution in [city]. Look at where we all live at.” And so they started connecting the dots and seeing that.

Another example of a climate and environmental justice topic that emerged when a math leader was sharing stories of former social justice examples in the classroom that involved mathematical concepts:

> And we have a look at some data of where there were these sort of landfills and Superfunds sites and oil and gas facilities and just all of those things that can be polluting and areas that have been polluted. And we looked at the data and overlaid that data with information about who lives in those areas. So, mainly what we were finding out or the conclusion that scholars were drawing or coming to was that a lot of times they were disproportionately placed in or around communities of Black and brown people of color, and so that was, I guess, the math piece of it because you have to do the graphs, you have to collect, do the percentages, things of that nature. And I think it was, how the students when they actually got to see that it was not coincidental that that occurred, almost to the extent that it could have been seen as purposeful. And so they had to draw some conclusions about what happened, how could this have come about, and consider ways that individuals could stop this direct impact of these sites on people of color.

Student readiness. Math leaders referenced the source of the social justice conversations indicating that they made efforts to ensure that students were the ones initiating the conversations

that centered on social justice in the mathematics classroom and that they (the leaders) were not the ones introducing the conversations. For example, one math leader shared, “A lot of our students, they wonder. And I wouldn't just like randomly bring things up, I would wait until I could infuse certain things at certain times when they brought it up.”

All five of the participants indicated that students were ready for these types of conversations. Describing it as an “enlightening” process, one math leader shared that most students would understand the conversations that were taking place surrounding social justice. Another math leader shared that students initiating the conversations were a demonstration of their level of readiness. As this math leader recalled:

> So it wasn't like it was hard for me. It was like fuel was given to me to say certain things. And so the kids never pushed back. I mean it was always like, “Okay, you right [math leaders name]. You're telling us the right thing. If we're considered ADHD and other things that they're giving you. Well, it's lead in these old buildings. It was lead in this pipe that's here.” So you know you look at all of those things and you share it with them. And so they get an understanding of what's actually happening.

Another math leader emphasized the importance that it was the students who brought up the conversations in the classroom, “and we kind of turned it around to make it more of a lesson...the young men were the ones that brought it up... Like it was ironic.”

Lessons from practice. One math leader shared an example of a discussion surrounding race in the classroom and inequity that centered Martin Luther King holiday. The leader shared:

> Whenever we talked about Martin Luther King, something would come up because especially when I had White and children of color in my class, we would just have discussions about it. When I look back, I don't think I said anything wrong, but I think I would approach things very differently now, and I think I'm still evolving on how I would approach that now.

This math leader used their classroom space to present students with the equity stance that all individuals are created equal regardless of your differences. When probing further into the meaning behind their statement, "I wouldn't approach it that way now," the participant responded that their more recent professional development experiences resulted in reflections on those practices and efforts to adopt an approach that values the space for speaking to the differences between racial and ethnic groups. This leader explained further:

> I accepted that everybody was different, but I said, "Oh, it's okay. We're *all* children, we *all* this the same." I would hate for, like, I wouldn't have even been able to teach some of you who couldn't be going to school together. I approached that, but then I'm not sure it was enough. So let's get to know each other's backgrounds and experiences.

Another math leader expressed the modification in their instructional practices to customize the curriculum and instruction to meet student's needs:

> I took a suggestion, and took what my kids, where they were from, and just kind of rolled with it and that's what I think is important--like very, very, very important. I didn't call it a social justice thing. I just called it, let's make it connect. Let's just make it connect.

This leader shared the story of how a collaborative effort with a colleague introduced them to customizing a lesson by placing different components into the context of students' lived experiences. They were able to see the evidence of this strategy manifested in increased test scores described by this leader as "...eye-opening. That was the first year that our math scores for [school] were over 90%! And we were like, 'What in the world?'" This same math leader detailed this practice of personalize math content as resulting in positive outcomes for their students:

> I used to take those same tests and change them. I mean it was the same question, but I used to take those tests, use the students' names, use the student's street addresses or neighborhoods or the grocery stores that were in their neighborhood. They had this test, and if I gave that test in a different way they always get better. So I stopped giving it the way I was told to give it. And just changed little things and it was very little details. And they're like, "Oh that's around the corner." And it's almost like they connected to this question. It's like oh yeah that makes sense. It didn't make sense if I call it, say [grocery store outside of community], but if I call it [grocery store inside the community], you know!

This same math leader continued by emphasizing the importance of relationships with students to support the effectiveness of this strategy. Specifically, the customization of a lesson or resource is only as valuable as the students' ability to make the connection to the topic and connection to the teacher. This leader continued:

> Teachers can change names and curriculum or change something on the test. But if they don't have relationship, none of that's going to work. I think that that is the one driving

> force. But I think that once you have this relationship, once you make sure that they are understood that you are *really* concerned about what is happening in their community.

Relationship building

Many participants in this study shared examples of student engagement and responses to social justice conversations in the mathematics classroom. Notably, participants provided examples of conversations that were initiated by students in the classroom. These reflections centered: (a) classroom culture; and (b) care and concern for students. These sub-themes are examined below.

Classroom culture. Math leaders described the importance of creating a classroom culture that was conducive to discussion. This type of environment supported students in building the skills to have conversations about social justice issues with peers and their teachers. When describing strategic efforts to create a classroom environment that supported social justice conversations, one leader explained:

> So you're gonna create opportunities where early on, your students have to tackle issues where they feel comfortable giving their opinion. Where they feel comfortable not only giving their opinion, but reacting to or responding to the opinions of others, including me. So you start off with things that are less challenging or that won't cause a whole lot of emotion. And then you can move into things similar to this when you're talking about race and class.

Math leaders also described some of the reactions of students to social justice conversions that occurred in the classroom. The concept of fairness emerged as one such response where students were provided the space to explore an ethical position to a social justice

topic. When examining the impact of pollution from an environmental facility, one math leader described student responses including, “That's not fair that that happened and that's why we wouldn't have to be. I wouldn't let that happen to my mom, my house, or my community.” This same math leader described student feelings of anger and disbelief that “there is that much injustice and racism in the world” as students engaged in dialogue about the social justice topics.

Notwithstanding feelings of empathy, there were some students who conveyed a sense of expectation when communicating their understanding of societal impacts and permissions in the context of wealth and socioeconomic status. For example, a math leader shared the response of one of the students who were part of the small minority of students who were not surprised by the injustice, stating, “Of course, it makes sense that these people would be the victims of this because they were powerless to this.” This math leader shared their students’ level of readiness to understand this social injustice as:

> My students were probably overwhelmingly quicker to understand that that's just kind of what happens when you don't have money. You don't have power. You don't have the resources to fight. Those kinds of things happen to you because you live in poverty.

One math leader shared an extension of the classroom conversation that led to student activism on social justice issues. When discussing environmental injustices, this leader shared:

> There were students that chose to write letters. It was not an official assignment. There were other projects and activities that would become like official projects. That was not, but there were students that didn't know with the information that they learned, that they decided to write to their--I believe it was their--not the general assembly, but their congressman about this whole “not in my backyard.”.

Care and concern for students. Math leaders described feelings of care for their students when describing social justice classroom practices. Teachers cared for their students as they develop these classroom relationships. While reflecting on experiences with social justice in the classroom, one math leader concluded a story about the different types of violence that impact the community by sharing, “Thankfully, no one, of course, that you know, got hurt at that particular time.” Another leader continued by sharing sentiments about the emotional attachments:

> It's like they’re family...where you just get to know the kids, the families, and then the siblings come through. And you just know you're comfortable with them telling you things and sharing things with you and just having an open dialogue.

The majority of math leaders shared stories of how they paused math instruction to tend to the social-emotional needs of their students because of instances of trauma, violence, or tragedy in their personal lives or in the community. One leader shared:

> There will be days when I will come in and we may not do math at all. Something may have happened where someone was shot in a community or something had happened on the news where someone was killed. In any case, you could just tell that they weren't there. Their hearts weren't in it. And so, we would just talk about how they felt about certain things.

Another math leader shared a story of an experience supporting a teacher whose class had experienced an event in the community that translated into the school environment. This leader's story speaks to the priority of tending to the trauma for the purpose of supporting students. This leader shared:

> I don't know what happened, but it was something that happened in the community because I went in there just doing walkthroughs. [Teacher] said, "[Leader], you might not want to be in here right now because we're not talking math, right now. Something happened across the way. And we're discussing that." "Oh", I said, "Well can I stay for a minute." [They] said that they will be honest and blunt. [They] said, "I don't tell them to hold their tongues." I said, "all right I'm out." I didn't want to be the barrier that silenced them in their conversation...Usually when in those circumstances like that, [Teacher] always tried to find a way to bring it back to the math.

Math leaders also described situations where they advocated for students of color as representations of social justice. One example, in particular, spoke to how the support and advocacy of a math leader could alter the trajectory of a student's academic experience. The example centered on students whose semester-long precalculus instruction was interrupted by the COVID pandemic. School closures led to students being unprepared to progress to calculus. This math leader shared their advocacy for the students and willingness to teach the course so that the students would be able to continue with the honors course progression. Their commitment was conveyed as:

> We can't be afraid to do the work. Those are our kids, no matter what position I do. They're OUR kids...So take all of the excuses away, you know they're throwing all these roadblocks. I want our kids you know. We're talking about equity. We're talking about underrepresented populations. I'm telling you that this will work, and that I will be the teacher. They'll tell me no. You can't tell me that.

Another example is of a math leader attempting to be the voice for students who had ineffective structural factors put in place to support them because of high teacher turnover. Consequently, there was a disrupted learning experience for students in a school that was unable to secure a qualified teaching professional for math instruction described as:

So they're supposed to do all of their math on [automated online education program], -- just sit there with headphones on all day. And listen, and again this is racist. All they do is sit in front of this computer, answer questions and get these printouts. So if this kid is already having issues with reading and comprehension. How in the world are they going to do that? Teach math to themselves?…So research says, 'If a kid loses a year of math.' That's why COVID is so terrible here. It takes three years to recover. Two years, they don't recover. So those kids were two years of no instruction. One year on a computer, halfway through and a teacher quit. So they got nothing. The next year, [several] teachers in one year. They didn't learn anything. So God only knows the impact on those kids.

Math leaders shared stories of reconnecting with former students as adults. Former students made connections to their experiences in the classroom and the reality of their existence in a society that is built around social constructs. A leader expressed how their work was validated when students returned and shared, "[Math Leader], everything you said was right." Former students of math leaders have assumed a variety of occupations including careers as math teachers and engineers. This math leader continued by sharing their feelings about this experience stating, "So that was like validating that the work that I did, even though they didn't see it, the seed was planted. And they knew what to look for."

Research Question 2

In what ways, if any, do math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities?

This section describes math leaders' perceptions on how to navigate mathematics curriculum, social justice pedagogy, and administrative responsibilities. Teachers who attempted to teach mathematics for social justice could have been in a position where they had to choose between the time needed to carefully construct a math lesson on social justice with professional responsibilities. District leaders who taught mathematics for social justice were familiar with this predicament and able to propose different approaches to this balance when they transitioned into leadership positions. The theme that emerged from the data was balancing three educational domains.

Math leaders were able to share stories of supporting teachers to provide a better understanding of how math leaders themselves achieved balance and in some cases supported math teachers when teaching mathematics for social justice. A vignette was read to math leaders about a teacher whose test scores were suffering because she was no longer able to implement social justice lessons. The lessons were competing with her ability to satisfy administrative tasks, such as attending mandated professional development, performing remediation, and completing lesson plans. The principal's story was included as well as an alternative perspective. Math leaders' reflections from this component centered: (a) teacher retention, (b) assessment as evidence, (c) empowered educator, and (d) administrative support. These sub-themes are examined below.

Teacher Retention

As the researcher began reading the vignette, one math leader shook their head and immediately interjected:

> My first thought is that it's us in this place right now. That's exactly what I feel because we have so much going on right now or providing or asking teachers to do as far as teaching to the test or teaching to a particular curriculum, without actually doing the parts of teaching that they really love and making it unique to them.

After listening to the vignette, the majority of math leaders shared that they currently or have supported teachers and/or have been in similar situations themselves. Their responses also brought up the issue of teacher retention as an issue that can emerge when there is an imbalance with social justice pedagogy and administrative responsibilities. In fact, one leader shared:

> I can completely envision that happening. And, I relate to that teacher. Because to me, this is just an example of what I think of as the teacher no longer fitting within the system. And, my solution was to leave the system. But obviously, then that doesn't improve the system.

Another math leader referenced choice as a factor as they shared, “Maybe a lot of people aren't like this, but if I can't [teach a social justice pedagogy] then I don't need to be here. I mean that's just where it is.”

Assessment as Evidence

Assessment as evidence is embedded in the structure of the educational system. Similarly, the importance of evidence of success emerged in all of the math leaders’ responses to

the vignette. One leader suggested that administrators need to allow greater flexibility when data suggest that expectations are being met. Another leader provided a story of a teacher who did not have the evidence of data to support student mastery, but did have evidence to demonstrate student growth and described the experience in the following manner:

> It's awesome to see the students' engagement with [teacher] because regardless of how they start a lesson, it always ends up with the math lesson that [they] wanted to teach...The first year [teacher's] principal dogged [them] about it...But I can definitely say you could see the growth in the students. And I know everybody just looks at scores. And I'm a stickler. I look at scores as well. But when I could see kids really wanted to run into a classroom, because they want to do the math or they wanna talk about this and do the math. Oh my God! It's just awesome!

The preceding example demonstrated how this math leader viewed teacher relationships as a crucial component in identifying and leading towards student growth. They noted that this school had years of low performance on standardized testing, but this type of mathematical experience in the classroom is the source of student growth. It is important, however, to note that one math leader did caution against the approach to achievement at the expense of student concept mastery. This leader placed particular emphasis on this as it relates to the different responsibilities that math teachers navigate, stating:

> You have all these different factors pulling at their time and discipline and all of that kind of thing. It's like they want you to get as many credits as you can, whether they learn the math or not teach them every trick you can teach you to get them to pass.

The pressure for time takes away from teachers' ability to engage in social justice practices that they often are not equipped to do. And being equipped to engage in social justice teaching, for those who are not familiar with it, requires supports. As another math leader shared," I just don't believe teachers have been equipped with the tools to possibly even feel comfortable doing that if you want to create a space to talk about race and social justice."

Empowered Educator

Considering the vignette, math leaders shared a variety of responses they would have provided in this situation. One math leader responded that they would support the teacher in realizing that she is the one with the power:

> Mrs. Taylor doesn't realize that she's the one with the power. If you understand the times that we live in, and you understand that the research and evidence is overwhelming as far as what has happened to children of color...research says, I should be able to teach real-world applications to the mathematics. That's what research says. Not to teach to a test, not to go to all of these meetings, but to formulate lesson plans that are engaging to my students and increasing agency and identity.

Conversely, other math leaders shared that the ultimate power to make decisions is not in the hands of teachers. The concept of "not worth the risk" is a reality to many K-12 teachers if they make an effort to challenge decisions or existing practices. At times, even math leaders perceived they are limited in their ability to change the curriculum and other structures that were in place. Therefore, as one math leader described, "There's always someone who's going to dictate what you're going to use. So then you have to take what you're going to use and apply it to make it work for you at this time and your kids."

However, math leaders provided suggestions on how math teachers who teach mathematics for social justice could work towards achieving some form of balance with administrative responsibilities. One math leader suggested focusing on small tasks, such as taking "the opportunity to adjust the curriculum to incorporate any real-world problem that tackles social justice." Describing their feelings, one math leader shared:

> Nothing frustrates me more when you already have lesson plans, right. I mean, why are teachers spending hours cutting and pasting those or personalizing them? ...Spend your time in your PLCs, getting to, that's where you can personalize and really get to, how can we change this to meet the needs of our students?

The above suggestion promoted relying on the collaboration of peers to customize lessons and discuss pedagogical strategies that can best meet the needs of students. Above all, math leaders agreed that ultimately some form of a lesson plan should be submitted as part of professional practice, or as one leader said, "If it was a lesson plan, take your social justice and put it in your lesson plan and show the principal how that is done."

Administrative Support

Math leaders referenced the value of administrative supports for teachers navigating the three educational domains. According to one math leader, principals should recognize that "time is needed for the teacher to do that. So there may be something else that has to be sacrificed. The number of hours in the day don't increase just for you to do these types of lessons." Math leaders also suggested that administrators support teachers who struggle with completing lesson plans. One math leader recommended:

> If you need a lesson plan to show, let us integrate her social justice piece into the lesson plan, because a lesson plan to me is the least of the problem. That's why I don't really focus so much on it. Like it's paper. It's something that you're putting in your visit. Yes, it's your guide, but you can take what she's doing and place it in the lesson plan.

Conversely, one math leader made note that there are times that administrative support may be a challenge because similar to teachers, there may be a "learning curve for the principal" and the reality that "some principals are not open to change." One math leader described that there are principals who "just want to feel like they have to make their mark. And those people you have to just kind of go a different angle."

Research Question 3

What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice?

This section describes math leaders' professional judgment and opinion on: a) the feasibility of teaching math for climate and environmental justice; and b) the professional development considerations to move a district of math teachers in this direction. Participants were asked to consider their social justice practices as classroom teachers and the support they provided in their leadership positions to identify areas of consideration for TMCEJ. Two major themes emerged from the data: (a) success contingencies and (b) design and delivery of professional development for TMCEJ. The following sections share the findings regarding these areas for consideration.

Success Contingencies

The findings from this exploratory study demonstrated several factors to consider the potential and possible limitations to advancing a TMCEJ initiative. Within this theme, the following elements were explored: (a) current social justice climate; (b) stakeholder buy-in; (c) hiring and retention practices; (d) national and state equity efforts; (e) benefit to all groups; and (f) curriculum limitations. These sub-themes are examined below.

Current social justice climate. Participants in this study expressed support for TMCEJ because of the current political and social climate that has drawn attention to the inequities that exist in society. In response to the question about the potential for this curriculum, one math leader perceived the current timing as a "great opportunity to be doing it because [district leadership] are so open." Other math leaders described an approach that centered climate and environmental justice as "wildly successful," "very powerful," and "It absolutely needs to happen!"

There existed a sense of urgency among all participants about collective efforts to support student learning by incorporating equity and justice-centered instruction. Math leaders framed these sentiments in their experiences with social justice efforts over the span of their personal and professional lived experiences. While considering over 20 years of practice in the field of education, one math leader shared, "You know, people talk about the social justice efforts continuously. We've been doing that. Yeah, we've been doing it, we didn't give it a name." Considering social justice practices in education, another leader shared, "It's both interesting and again depressing as hell that we kind of come back to the same place."

In terms of climate and environmental justice as a crisis to historically underrepresented groups and the economically disadvantaged, one math leader described feelings of dismay when reflecting on the *Freedom to Breathe* series (PBS, 2019) watched prior to the interview, noting:

> That's still a conversation that we're having about the disproportionality that exists with the impacts of climate change, pollution, and everything on communities of color...air and water pollution, on our economy, on our culture, on labor, on all those things. Like, there is a wider impact than what we can see sometimes and that we realize.

There was, however, a consistent question that emerged across the group of study participants in reference to the Freedom to Breath (PBS, 2019) docuseries episode that featured Port Arthur, Texas. This town, with a large Black and Latinx population, is home to one of the country's largest oil refineries. In 2017, Hurricane Harvey impacted Port Arthur with record flooding that was a result of climate change tripling the amount of rainfall. The majority of the town was submerged under toxic water because refineries shut down and millions of pounds of emissions above the allowed levels were released into the floodwaters. Two years after Hurricane Harvey, most of the bottom units of an apartment complex in Port Arthur were still uninhabitable and residents remained displaced. Several math leaders were puzzled by hearing the bottom level of the apartments remained uninhabitable and questioned the location of the displaced tenants. As one leader shared:

> The same thing about when the community was flooded. And I thought about that and I'm like, how can a whole bottom layer of a community still be destroyed! And we're looking at the apartments. I said, "People still live upstairs with the mold and everything!" I was like, "Why am I looking at this?" Literally, I was like, "I don't

> understand! I don't understand!" And like the man said, "In all this time, where's all the people? Where did they go?"

Stakeholder buy-in. Participants described the necessity of buy-in from stakeholders at various levels to even consider the implementation of TMCEJ at the district level. Buy-in is defined, in this instance, as a stakeholder's willingness to actively support the curriculum. Equally prioritized among participants was the importance of teachers embracing the effort to teach mathematics for climate and environmental justice. There was the anticipation of push-back from teachers who would display resistance to implement the curriculum. Central office personnel and parents whose students are members of the school system were also identified as key stakeholders by math leaders.

Reflecting on experiences with support or opposition to past district efforts, one math leader shared the importance of ensuring all members of the community have an active voice in this decision-making process. This math leader spoke to the importance of equitable voice, suggesting:

> It will take the voices, not the 20% that's talking because those 20% are talking and they're talking loudly. So, therefore, that is who people listen to. So, in order for us to really implement a social justice stance, regardless of what course or content we're talking about, we definitely have to have community buy-in.

Lack of flexibility and limited mobility were perceived as two of the reasons that parents with low socioeconomic status are not able to participate in decision-making meetings. However, the voice of the wider community is impactful as described by a math leader when students were temporarily moved to another school when their school building was being rebuilt. Members of

this community with low socioeconomic status were able to mobilize to demand that their children receive schooling in their own neighborhood. This math leader shared:

> The parents in the community were upset because they didn't trust that their kids would get a fair shot at some of the other schools. Those teachers at the other schools aren't used to teaching kids like our kids. So that was the big stink.

This scenario is an example of what a math leader described as how the collective good should be centered in decision-making processes, even if it is one person taking a position to say, "No, you can't have it your way. This is what is good for ALL of our students, not just for your subgroup of students. For all of the students, even yours!"

Math leaders collectively agreed that embedding math content into a climate and environmental justice frame, or any justice frame, would result in strong opposition and be "just as big a fight as any other bit of progress that we are trying to make." Learning about a TMCEJ approach, or even a teacher presenting academic content from this lens, could be viewed as controversial to certain individuals. At varying degrees, each participant shared ideas about how to proceed with this interaction. One math leader suggested, "There may be some courageous conversations that need to happen with parents to let them know this is the approach that the district has taken." These conversations can convey the use of math to have discussions about data because, as one leader shared:

> Math takes the emotions out of it. Math is one of those areas that you would think we would be able to have some of the social justice discussions and arguments and whatever, a little less emotionally than we normally do. Because I mean the math is what the math is, right? The data says what the data says. Like, it's not just a thing that Black women

> have made up that they are more at risk of becoming pregnant and going through pregnancy than a White woman. That is data that exists. But yet and still, when they go to the doctor, it's not data that is used and you would think because math could be the potential to take the emotion out of it.

Conversely, one math leader shared the difficulty of a TMCEJ initiative moving towards a state of implementation without evidence to demonstrate its effectiveness. Unless a case can be developed to use this approach with data to support it, the probability of success would be very slim. This math leader shared:

> With this social justice, or climate justice, or whatever, the mindset needs to be the problem. I find in these kinds of discussions, unless the teacher and or the school knew enough ahead of time to collect the data, it would be hard to prove that that's what the reason is. And with the focus on data-driven stuff, without that making that case and winning that argument, I don't feel like the chances are very good in most places.

Should these obstacles be successfully navigated, math leaders initially held various perceptions of whether or not to mandate participation in the curriculum from the district level. However, after detailed thought, all math leaders arrived at the conclusion that district-mandated participation is the only way to implement the curriculum with fidelity to ensure that all students benefit from the perceived value that it would bring. As one math leader reconsidered their position, they stated:

> So now I'm kind of rethinking when I said that it has to start small and grow bigger. I think it really needs to come from the top. I need to say this is what we believe in. This is

a philosophy that our school division has. This is important and this is what we need to do.

Math leaders agreed that all levels of district staffing should participate in learning about the curriculum and that "training for us will be formal that has to be at the top." This process could also result in staffing personnel to make difficult decisions because, as one math leader shared, "It also might be the place where you figure out the teachers and the staff who don't fit with the values and the things that you want to teach in your district."

Hiring and retention practices. When considering resources necessary for a new paradigm shift, such as a TMCEJ initiative, math leaders shared concern over how staffing issues could potentially hinder the full implementation of the mid-Atlantic state's equity initiative in Title I schools. Specifically, regardless of the framework used, Title I schools will often face challenges staffing and retaining qualified teachers. This was a concern about implementing a new framework, establishing quantitative measures of success, and using data from a TMCEJ initiative as a measure of student achievement because students achieving at the same rate is practicing equality, not equity. As one math leader shared:

> And so, if you start a new way of teaching and say, "Well we're gonna try this." [Fully accredited school] is more likely to say, "Alright let's try. We're playing with fool's gold here. We're always accredited. We have great kids. No matter how we present them material, their parents are not going to let them fail. And so, they're going to be fine. If you go to a Title I school that's being threatened to being taken over and administrators saying, "Look, teach to this test, make sure the kids have got this," then that's a whole different arena.

This level of awareness resulted in math leaders' commitment and feelings of obligation to serve students in Title I schools. Many staff chose to work in the Title I community because it provided them with the feeling of giving back to their community and commitment to underserved populations. While one math leader provided an example of math staff at a Title I school that were fully vested in positive student outcomes, the majority of math leaders referenced the difficulty of staffing Title I schools and the importance of ensuring that individuals serving students in Title I schools were representing the best interest of students, particularly in mathematics. One participant shared, "They couldn't get a job anywhere else. They got their foot in the door here and as soon as the door opens somewhere else, they're out of there." A second respondent shared that pay is a factor in why some teachers have chosen to work at their district, stating:

> We keep increasing the pay [and] people are coming. But do we really want them? You're not coming for our students; you're coming for the money. And therefore, you're still not doing what's best for our students. So I'm like, "No, we'll just wait."

Therefore, participants demonstrated the paradox where on one hand you have a staffing shortage and on another, the motives of staff are questioned. Consequently, the least desirable courses are the ones that experience staffing challenges. An example is 8th-grade math, where there is a larger percentage of students considered below grade level because the course is often waived for advanced students who matriculate to Algebra I. As one math leader said:

> You have the geometry kids. They're gonna be fine no matter what building you're in because somebody's gonna say, "I'll teach those kids." The algebra kids are gonna be fine because someone's gonna say, "I'll teach those kids in eighth grade or seventh-grade

> algebra.” It's the other ones. It's the 8th-grade math where everything is left and the kids have a low identity of themselves, no student agency on themselves. And so, no one wants to teach those classes and so you get what you get.

Not only were student agency and low identity a risk from staffing issues, but students were at risk of receiving low-quality instruction. At the threat of takeover from the state department, administrators may communicate to staff, “Look, teach to this test, make sure the kids have got this.” The consequence then became students receiving instruction on test-taking skills rather than instruction for conceptual understanding that supported the construction of a positive math identity. Another leader introduced the importance of external supports that were brought into schools as turn-around partners. Though their work is contractual in nature, their work impacts staff and students. In recounting such an experience, one leader shared: “I felt like they viewed race as a given obstacle that was going to result in lower performance. So, a deficit approach. I think so. And I mean not because they came right out and said it.”

One leader proposed consideration for ensuring the right people were staffed for the job sharing:

> Put everybody's name in a bingo hat and pull them and these are the five you bring down to the office so they can have a conversation. The good one, put her name in, the exceptional ed student, the bilingual student, the EL student, the student who just got suspended because he was in a fight. It don't matter. Bring them on in here. Because this is the person the teacher is going to be in front of them all the time. So I think we definitely need to do something differently. We need to change the way we hire. And that's just in education in general because some people just don't belong in some places.

Though the above quote references a teacher being the one who is interviewed, this respondent made particular mention that this approach should apply to administrators and central office personnel as well.

Findings from this study demonstrated the need to examine an individual's core values and beliefs because they can and do impact equitable practices in the classroom environment. One leader shared:

> Yes, you want a body. You want a licensed body and that's all we care about. Did someone take one minute to Google this person's name and see what their social interactions are? It takes a minute. It literally takes a minute. And you didn't do that. So then you expect for this person, who in 'Social Street' has this, and then you expect for them to come here and do this with the same group of kids that they're talking negatively [about] or people that they're talking negatively about over here. That could have taken you a minute to find out.

Yet at times, hiring practices and teacher retention efforts came at an expense because, as one leader noted, "We've gone to this extreme in education about providing support and sort of allowing everything. Where we shouldn't allow everything. Things that are wrong should not be allowed." Furthermore, this study showed that race could be excluding if it was used as the sole determinant of the measure of a candidate's ability to understand the experiences of students in Title I schools. In fact, one math leader shared that they had "seen Black teachers do the same thing to our Black students. And it's like, um naw. We're not doing that." In these situations, math leaders intervened on behalf of students. Another math leader proposed that the disconnect may exist within the construct of class. According to this leader, "All of our Black and White

teachers may not understand. Because sometimes I think it is not so much of race anymore, as far as where it is the economically disadvantaged that people may be disconnected from."

National and state equity efforts. The topic of equity initiatives in education at the national and state level emerged as math leaders discussed the feasibility of embedding mathematics in a climate and environmental justice curriculum. One math leader mentioned early in the conversation that resources on equity and access secured from the National Council of Teachers of Mathematics (NCTM) were referenced in professional development sessions, yet they "see all the research in the math, and it doesn't always apply in practical circumstances in the classroom or within our classroom." Conversely, this same leader and others responded favorably to the current efforts of the mid-Atlantic State Department of Education to dismantle inequity in the public educational system by establishing equity goals and initiatives. The Department of Education established an internal division to spearhead these statewide efforts and disseminated information to members of the public community. Math leaders made reference to these statewide initiatives as they reflected on their social justice practices and the potential for TMCEJ. For example, one leader shared that the "changes that [mid-Atlantic State Department of Education] is making to our math program, or trying to make to our math program, I think this is the perfect time for us to really have these conversations right now." Another participant shared they "like where the [mid-Atlantic State Department of Education] is going with the de-tracking" because:

> It's going to take many years, but to have much more. But you know that you're not on this track and that you can mix and match in the real world. Like if you're an artist, you're interested in art, you could take your job geometry...and it's not just this track like we have now.

Though favorable perceptions of equity and access are a forefront objective of these initiatives, math leaders expressed sentiments of cautious optimism about the efforts surrounding the topics of curriculum and staffing. All math leaders referenced the overarching state-mandated curriculum, at times referred to as "the system." First, several math leaders expressed concern about how effective efforts to dismantle inequity in the public education system could be if the curriculum itself does not embed social justice topics in addition to representation of historically underrepresented groups. Reflecting on their leadership experiences, one participant said, "Well, just my experience of how things tend to run in K-12, at least, public k-12, is that it's all driven by the curriculum." Another leader paralleled their experiences on working on the curriculum in another state to their perceptions of the true root of limitations to changes in equity sharing:

> The [state outside of mid-Atlantic state] actually has all of these restrictions in place about what is allowed, including in their textbooks, in their examples in student works, the kinds of problems on standardized tests, like all of this stuff. And I always used to hear from publishers that there's a California edition, there's a Texas edition, then there's an edition for sort of, and I never really thought about it...It would be tough for a teacher in [state outside of mid-Atlantic state] to address much of anything by way of social injustice or climate change because they would probably be in a bucket of forbidden topics.

Benefit to all groups. Math leaders in this study placed value in TMCEJ because of its potential benefit to students from all backgrounds, including students who are members of historically underrepresented groups and the economically disadvantaged. The teaching math for social justice approach supported students in learning about the realities that exist relating to

inequalities based on social constructions that were primarily excluded from the educational system. One leader stated:

> They didn't know. They really honestly didn't know that a Black man, a Black person could be that angry. And I'm like, “What”? Because as a kid you don't understand or you don't really see it. Because we don't talk about it in class. We don't talk about it at schools. They just see all of my friends run around. They see “I stay with this group of kids.” But they don't understand that that is a conscious separation.

Another leader shared the importance of considering socioeconomic status in terms of how this topic is relevant to students in other areas of the mid-Atlantic state who may not have students of color in their student population:

> I couldn't help thinking about including poor White in that category, as well as part of where I grew up in [state] had a big oil and gas boom that resulted in a very similar kind of situation where the people who had nothing but this little hunk of land. It wasn't good enough to farm or to graze, but they maybe had an oil well or a natural gas well. And there was a pretty big population of, I'll just call them exploiters, and to drill or to look or to whatever, and made these arrangements with largely uneducated or poorly educated people who didn't read the fine print didn't know that just because it's on your land doesn't mean you own it. If you sign this thing and give me gas rights or mineral rights or whatever, what that means for you and then they just left and left the mess left the environmental detritus.

Curriculum limitations. Equally introduced in the responses of all math leaders was an overarching state-mandated curriculum, at times referred to as “the system.” These leaders

proposed that in order to create an equitable frame, the narratives of all voices must be represented in curriculum resources because the content is required and accessible to all divisions and districts across the state. Representing the voices of diverse racial and ethnic groups helps to minimize situations similar to what one math leader described as a controversy that emerged in a state over the historical account of Native Americans and land ownership that was "making it sound like they welcomed these White people and just handed over their land. It's like, that's not how it happened. But, there's potentially millions of little [state outside of mid-Atlantic state] children who now think that's how it happened." This math leader continued by providing a context to understand the significant implications of not correcting false historical narratives:

> When you realize that though, it does help you understand some of the recent news reports. Like when you see these people being interviewed on Fox News and they say things that are just so historically wrong. And you think to yourself, "How can you think that that is a true statement?" Right? But I bet if we were to go look at where they went to school, and potentially what curriculum restrictions, whether spoken or unspoken were sort of in place in those areas, I bet you would find a connection.

Another math leader shared the importance of approaching this work with constant consideration that even with the greatest intentions, it is important to perform a close examination of the narratives that are being advanced as factual. This leader presented the following example when exploring the potential for an interdisciplinary approach:

> Even though we agree that it should be interdisciplinary, I'm not going to necessarily accept your version of the story. I'm not going to do this just for the sake of doing it.

> We're going to really try and put the event in the middle and look at it through everyone's eyes, not just European eyes. So there could be some pushback from that. For instance, if we did someone like Abraham Lincoln. You think he's a great emancipator. Abraham Lincoln didn't like Black people. So I'm not going to subscribe to that part of it and further jeopardize our kids into misknowledge as far as who he was. You want to say, "He did this; he signed the Emancipation Proclamation." Well, that's fact. But you know what, he also said he would like to send us back to Africa and he also said that they were superior to us.

Consequently, math leaders suggested that curriculum decision-makers use a very specific lens when selecting the curriculum that would be used to support these efforts because "with so much money at stake in fields of education, it's hard to weed out the people who are truly trying to put students and learning first." Therefore, it is important that decision-makers critically examine resources and the motives behind curriculum suggestions. One leader suggested:

> I feel like most of us don't recognize how important who we put in those positions is and how important it is that those people are well educated in terms of what their choices are. And not just going by the shiny presentation over lunch that had the best sandwiches...Are they choosing it because 'It's the company I've heard of because they've spent a million dollars on advertising and they have the shiny little flyer that they send me every single month?' Or are they picking the company that says, 'I'll do this highly customized personalized thing for just your school?" I think the same kinds of decisions are made at school board levels.

The recommendation was advanced that districts locate “ethical, not for profit” and “well-respected” sources who are “already funded by something outside so they don’t have to worry about money,” such as National Geographic and PBS. Therefore, the conversation could be advanced that:

> We want to have this focus. Can you give us some curriculum resources, not necessarily the whole thing, but let's say a unit for each of the subject areas? And then you could build professional development around those things initially.

In addition to a closer examination of the curriculum at the state level, participants' reflections conveyed perceptions of limitations from the existing math curriculum. Expressing a sense of optimism, yet uncertainty, one math leader posed the question, “How do we integrate it in the curriculum that we have? Because though we can talk about social justice, but embedding it in the curriculum, [name of current curriculum], may be a little bit trickier.” In the majority of the responses, math leaders discussed ways to implement the climate and environmental justice topic in the existing curriculum versus considerations for a newly-created curriculum. These responses included, “I would love to have something like that embedded if it could easily, like I said, if it doesn't impact how we get through the curriculum.” Another leader shared, “You would have to spend hours and hours changing every problem to meet the needs of your kids.” In speaking to the current climate that is embracing social justice movements, a math leader shared:

> This is probably the time in which we could roll something out to [senior curriculum decision maker], as long as we were using the existing curriculum. But you know, maybe that really is the issue. And maybe that's why we don't have the engagement that we really should have because they don't see that connection to them.

Design and Delivery of Professional Development for TMCEJ

As participants shared their feedback on the possibility of TMCEJ at the district level, various considerations emerged relating to the implementation of this task. Participants in this study shared their perceptions on the various components of implementing a climate and environmental justice curriculum that included: (a) professional development supports, (b) implementation, and (c) topics for discussion. These sub-themes are examined below.

Professional development supports. Math leaders agreed that professional development supports needed to be in place to support this effort to embed mathematics in a climate and environmental justice framework. Leaders shared their belief in the support of an outside partner to implement the curriculum at varying levels. Some leaders did not make reference to external partners but shared perceptions of the potential of a collaboration of existing staff to accomplish the task. Other leaders presented the need to have external partners with expertise in the subject matter to provide professional development on the content and pedagogical delivery of TMCEJ. As explained by one math leader:

> There will be collaboration and intentional opportunities for collaboration with teachers. There would need to be some performance support with professional development. Because, doing these lessons don't come naturally in classrooms where traditionally, it's been about sit and get and covering SOLs and being on pace with lessons that don't require deep learning. So there have to be some professional-level supports around that material.

Regardless of how professional development is delivered, math leaders agreed to the necessity of the process being “planned very well, and teachers would have to be given a lot of

support to do this. But, it could totally be done. But it is not one of the things that is going to happen organically without some intentionality behind it." Math leaders also supported careful and thorough planning as a way to counteract the pushback that would emerge from various stakeholders. In doing so, it is important to have discussions "rationally and objectively and make policies and plans and procedures that really do what we say." As one math leader shared:

> You have to provide the professional development. I think too many times, we get pushback because teachers are like, 'Oh, it's just another. We got to change again. It's another thing we do what they tell us to do but they don't tell us how to do it." They really need purposeful, valuable professional development.

Embedded in math leaders' perceptions of TMCEJ was the emphasis on supporting stakeholders with the development and continued growth of a critical consciousness that is necessary to address topics of equity. One leader described that when placed in uncomfortable situations, adults tend to "shut things down as quickly as possible." Still, some participants agreed that members of the educational community need to participate in these conversations as part of a continuous growth process:

> And they have to be able to say, "Okay, this is a room that what I say is not going to go outside of this room. I can stand and still be able to walk away feeling that I am empowered to do the work that you're asking me to do. But I want you to understand, I don't agree with it." Well, that's okay. You gotta be okay and we got to be okay with saying let them have their way. Everybody doesn't have the same mindset.

Supporting stakeholders with these conversations is necessary to translate to the classroom environment as well. One math leader shared that staff need to learn how to create a

welcoming classroom environment that begins with an “attempt to address your own biases” and developing an understanding of how to “navigate those conversations” that may emerge during math instruction.

Implementation. Math leaders referenced several factors for consideration when implementing a climate and environmental justice curriculum. Time is one factor that needs to be considered at the district and administrative levels because, as one math leader shared:

> These lessons can take longer, and that’s ok. Because while teachers may not be able to cover more standards with these longer lessons...the students are learning deeper. And they're learning at higher levels on Bloom's creation, evaluation and application. So it's not just a low-level means of acquiring or covering the standard. So, a willingness of administrators and districts to say,” That's okay, take a little bit longer.”

As represented in the population of math leaders selected for this study, the focus is on TMCEJ in the middle school setting. Notably, some math participants made reference to the importance of addressing student growth in mathematics in early elementary grades to prevent middle school teachers, who would implement this curriculum, from having to take long periods of time focusing on scaffolding to support students in accessing grade-level content. A math leader emphasized:

> Until we do that and get serious about it, we're always going to be in this mode of, ‘I don't have time to do what I need to do because I got to make sure that they understand these basics,’ because they don't understand it very young.

Math leaders agreed that initially presenting small portions of the framework and piloting the effort in certain schools is one way to address the concern of time and supporting key

stakeholders in becoming acclimated to the climate and environmental justice curriculum. Adding small components of climate and environmental justice topics to the lesson is one way to support leaders, students, and teachers in becoming acclimated to the new topic and learn how to best support other classes with onboarding. For some study participants, this included embedding "bits and pieces of that in the regular student lessons that they're getting from their teachers or adding it to assessment items, making it the context of the math story problems." Another idea proposed by a math leader was structuring the first few minutes of the class period for the purpose of implementing some aspect of a climate and environmental justice topic connected to the math curriculum. It was also recommended that teachers expect the possibility of low student engagement when it is first introduced. One leader suggested:

> We're going to use the bell we got to talk about this topic, and this is the topic for the month...Let's say we're talking about farming or whatever the thing is, this is our bell ringer, let's talk. The kids may be quiet for the first few sessions. They don't know what to say or how to say it, but kids, they loosen up when they know you are genuine and you're going to stick with it. And those are little subtle things that we can do now.

Piloting efforts could also be used to support the roll-out of the curriculum and make necessary adjustments by considering "where the errors are where we could make things better or clarify things as we need to at a smaller level." As math leaders explained, piloting the effort would have the benefit of minimizing continuous changes in the program that negatively impact key stakeholders' perception because "everybody sees mass confusion."

Math leaders perceived measures of success as a critical component of the implementation and survivability of a climate and environmental justice curriculum for the

mathematics content area. Measures of success were often referenced when math leaders identified the key stakeholders necessary for the support of the curriculum. Not only did all five participants identify teachers as the key stakeholder, but they also identified teacher implementation as an important measure of success. Various math leaders provided recommendations that included the inclusion of teachers who support this strategy or who are willing to "champion this by doing it" and having teachers who are comfortable serving as "exemplars who can lead." One math leader suggested that after a piloted introduction of the curriculum and its evidence of success, leadership could "figure out who's doing it the best, and you get them involved in sharing with those who are not doing it."

Assessment data was also considered a crucial measure of success because "nothing convinces the teacher more than the success of students if something's gonna work." Part of teachers piloting the curriculum and participating as voluntary exemplars is the ability to compare data as a measure of effectiveness. Comparing the class that is engaged in the TMCEJ curriculum with a class that is engaged in the traditional curriculum allows teachers to "build up the results in their classes on the same test compared to maybe teachers that didn't do those particular lessons and let the data then speak for itself." Math leaders also agreed on the importance of assessment data for other stakeholders involved both internal and external to the daily operation of the school system. There was also the importance of considering various data points to measure the effectiveness of the curriculum because "it doesn't have to just be test data. It could be overall classroom engagement more so than an assessment that wasn't readily available."

At the conclusion of the year, one leader described the evidence that could emerge of the connection between the various topics and the global topic for the year. This evidence would

allow stakeholders to have a better understanding of the curriculum and the potential benefits to the wider community.

Topics for discussion. Math leaders presented varying degrees of intersection between mathematical concepts and social justice topics, including climate and environmental injustices. Some leaders were not able to draw immediate connections between the border mathematical strands of number sense, computation, and climate and environmental justice topics. One leader expressed uncertainty about how to teach "ratios or multiplying numbers or you're following two-step equations. How that easily translates into sometimes social justice lessons." Another leader considered that "it's really hard to have x equals four kinds of answers to topics like this. They're usually much more complex and a lot of it depends, the best answer depends on which variable you consider the most important."

Within the mid-Atlantic state mathematical strands, all math leaders agreed that climate and environmental justice topics could be infused into statistical analysis. Some even proposed no need to have all math standards paired with a climate and environmental justice topic as long as "it is fluid enough that we can embed things in it that makes sense to kids." For example, one math leader explained:

> You think about the food deserts and in our communities, the grocery unit and all that. But you can see a liquor store on every corner as you think about all of that. And we don't even know what it looks like to farm anymore. It really does change perspectives. I understand we talked about gentrification and all that kind of stuff, but our kids don't know that anymore. I don't know if these conversations are truly really happening at a level anymore and it needs to be.

These climate and environmental justice topics mentioned above are relevant and occurring with the mid-Atlantic state that is the setting of this exploratory study. One leader described their perception of how students could utilize the topic of natural gas pipelines, the connection to mathematics, and the ability to build community within and outside the classroom to build mathematical agency. This process would help build student collaboration and activism by allowing them to "have their side and do their research, whether they're for it or not. They can still understand both sides of the story." This math leader further elaborated on this example while explaining how to counter current mathematical pedagogy that frequently leads to the misconception of math as having a singular method to arrive at an answer or always having a singular solution. Explained in this context:

> We always say, "You have to do X, Y, and Z." No, you can get to the endpoint and have various different ways where they can come to the conclusion, whether they agree or disagree. By doing certain things to impact their understanding of why and how the pipeline would have negatively impacted their community and made someone else outside of their community, a whole lot richer.

Another math leader described their perception of a void in math conversations in their reflection of the *Freedom to Breathe* series:

> If you focus on, or just like now with the coronavirus, and Texas deciding to open up everything to 100%, to throw out all the masks. If the variable that you value the most is money, people making money, businesses making money, having money to pay the rent, or whatever you're going to do with it, then that might be the best answer. If the variable you care about the most is the number of lives saved or sickened or hospitalized, then that

might not be the answer that is the best. And so, what I think we're missing in the United States in our math conversations is that component that the right answer depends on which variable or variables you're weighing as the most important ones. Because you can make a case for practically anything depending on what thing you weigh is the most important.

Not discounting the experiences of the other types of injustices by members of historically underrepresented groups, one math leader perceived climate and environmental justice as a broader topic that allows for the exploration of a wider span of injustices:

> That really could impact them with the climate justice. That's a bigger piece that we don't know and could potentially have more connections to the mathematics, other than 50% of our kids go to jail...We have these great conversations around social justice as far as the justice system. But we don't have it in all other factors that really impact our lives. I may never be in the justice system. Everybody who lives in poverty is not a part of the justice system. But they are part of all this stuff that these videos show. And they may not even know it. So I think that is where we as teachers or we as educators can do a better job. And I know our focus, really from my standpoint, I have seen that our focus really is on the justice system. You got to do this to stay out of jail, you got to do this stuff. It's all about that. I don't necessarily ever hear, “Well, what can I do to make sure our lives are better?”

Math leaders perceived TMCEJ as a topic that allowed for the disruption of other inequities situated within the topic. Consequently, there was the perception of benefits for all students.

Conclusion

Math leaders provided a wealth of information for exploring their perceptions of the practices in their classrooms that demonstrated teaching mathematics for social justice. In addition, they provided stories of how they navigated the educational domains of the dominant math curriculum, social justice pedagogy, and administrative responsibilities as classroom teachers and math leaders. Using their professional practice and wealth of experience as a guide, math leaders then provided perceptions of the feasibility, recommendations for implementation, and considerations for TMCEJ. The key overarching findings from this study were: (a) Math leaders used social justice topics that engaged students in learning mathematics and disclosing inequitable social constructs that exist in their worlds; (b) Math leaders engaged in practices that supported a relationship building within and external to the classroom environment; (c) Math leaders perceived importance in central office support, administrative support, and teacher empowerment to navigate the three educational domains; (d) Math leaders perceived the potential for the success of a TMCEJ initiative, yet identified several factors that may hinder the success of this effort; (e) Math leaders placed varying degrees of importance on different factors related to the design and delivery of a TMCEJ initiative; and (f) Math leaders made overt and covert references to the restraint of the state-mandated curriculum throughout the study.

CHAPTER 5: CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

This chapter presents the conclusions, discussion, and suggestions for future research from qualitative research. The purpose of this study was to explore math leaders' former social justice pedagogical practices as classroom teachers to inform professional development centered on teaching mathematics for climate and environmental justice (TMCEJ). An important aspect of this undertaking was exploring how math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities. This research also sought to learn more about math leaders' perceptions of the intersection of climate change, social justice, and mathematics education as an opportunity for teachers to engage their students in critical conversations surrounding these topics that are often part of their students' lived experiences.

Literature Review

The bodies of literature that supported this study were teaching mathematics for social justice and climate and environmental justice. Critical Race Theory (CRT) was the theoretical framework applied to this study because it supports researchers in placing race central to the research (Delgado & Stefancic, 2017). According to Esmonde (2014), implementing social justice in the math classroom has value for students when discussions of race and racism are thoughtfully planned (Esmonde, 2014). Instructional planning to support the space for mathematical investigations of social justice requires teachers to successfully navigate the curriculum requirements and social justice content (Bartell, 2013). Social justice pedagogical considerations may help facilitate the application of mathematics education to climate and environmental inequities that are experienced by members of historically underrepresented groups. Together, CRT and social justice pedagogy support K-12 teachers in TMCEJ by helping students build mathematical literacy, positive academic experiences, and community advocacy.

Methodology

A basic qualitative research design was applied to this exploratory study and had the central characteristic of enabling the researcher to explore math leaders' social justice pedagogical practices and perceptions of TMCEJ (Merriam & Tisdell, 2015). The goal of the study was to obtain insight into math leaders' perceptions of social justice pedagogy and TMCEJ. Purposeful sampling was conducted to best ensure participants represented the characteristics of the study (Maxwell, 2013). The sample comprised five math leaders who worked in five districts across a mid-Atlantic state. Math leaders were selected based on four criteria. All participants: (a) taught mathematics for equity, access, and/or social justice; (b) were current or former math leaders; (c) had a minimum of one year of experience teaching math in the classroom setting; and (d) had at least one year of teaching or leadership experience in a Title I middle school. The U.S. federal government designates a Title I school as a school that receives additional federal funds to assist with instructional and related resources based on the high percentage of students eligible for free and reduced lunch (U.S. Department of Education, 2018). For participants recruited for this study, teaching math for social justice was defined as supporting students in using mathematics to: a) critically examine unjust social, political, and/or economic structures; and/or b) consider ways they can participate in transforming these same structures at the local, national, and/or global levels. This definition was influenced by the work of North (2006) and Westheimer and Kahne (2004).

Summary of Findings

The following section provides a summary of findings from this study on TMCEJ. The research questions that guided this study were:

- RQ1 What stories do math leaders share about social justice practices in math classrooms?
- RQ2 In what ways, if any, do math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities?
- RQ3 What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice?

Five central themes emerged from the analysis of the data that were used to answer the respective research questions: (1) generative themed topics; (2) relationship building; (3) balancing educational domains; (4) success contingencies; and (5) design and delivery of a TMCEJ initiative. A sixth theme, curriculum limitations, emerged in the data with implications across all three research questions. The findings that informed these themes are summarized below in the context of the research questions advanced for this study. These findings also informed the conclusions that are drawn about math leaders' practices of teaching mathematics for social justice and the implications for TMCEJ.

First, math leaders shared practices used to center, draw student attention to, and/or initiate conversations about racial inequalities. Participants' responses provided information about the intentionality of math leaders' efforts to support students in using math to gain deeper understandings of the conditions in the students' lived experiences that were the results of inequitable social constructs beyond their control. Two major themes that emerged from the data were: a) inequity-infused topics, and (b) relationship building. Table 5 describes the summary of findings from these themes.

Table 5

Summary of Study Findings Organized by RQ1

RQ1: What are the stories that math leaders share about social justice practices in math classrooms?
Overarching Theme: Generative Themed Topics ● Math leaders, as classroom teachers, supported student's mathematical development by presenting real-world social justice examples with both operable inequitable social constructs and math applications. ● Math leaders produced generative themes to support social justice conversations in mathematics. ● Math leaders made conscious efforts to infuse mathematics instruction into social justice topics that were introduced by students. ● Math leaders engaged in lesson customization to practice student inclusion by inserting students' familiar lived experiences in the mathematics instruction as a form of engagement in teaching mathematics for social justice. ● Only some math leaders described stories of students critically examining and identifying examples of social injustice and transforming these responses into activism to impact change.
Overarching Theme: Relationship Building ● African American math leaders described speaking to students using personal pronouns of "you" and "we" when engaging in social justice pedagogy.

- Math leaders described the possibility that socioeconomic status may be the primary inequity that is a greater mismatch than race in terms of disconnects between teachers and students.
- Math leaders described stories of advocating for the participation of students of color in gateway courses to accessing higher level mathematics, such as Algebra I, as a social justice practice.
- Math leaders paused math instruction to meet emergent social-emotional needs of students and eventually bringing it back to the mathematics as a social justice pedagogical practice.

Second, math leaders' shared perceptions of how to navigate mathematics curriculum, social justice pedagogy, and administrative responsibilities. Teachers who attempted to teach mathematics for social justice can be in positions where they have to choose between the time needed to carefully construct a math lesson on social justice and professional responsibilities. District leaders who had taught mathematics for social justice were familiar with this predicament and proposed different approaches to this balance now that they are the ones in leadership positions. Table 6 describes the summary of findings from this theme.

Table 6

Summary of Study Findings Organized by RQ2

RQ2: In what ways, if any, do math leaders navigate the dominant math curriculum, social justice pedagogy, and administrative responsibilities?
Overarching Theme: Balancing Educational Domains

- Math leaders described teacher retention as a risk for teachers who may not feel supported with the delicate balance necessary to navigate the three educational domains of dominant math curriculum, social justice pedagogy, and administrative responsibilities.
- Math leaders had perceptions about the ways that teachers, administrators, and other math leaders could support the navigation of the three educational domains.

Third, math leaders then shared their professional judgment and opinion on the feasibility of a TMCEJ initiative and the professional development considerations to move a district of math teachers towards implementing a TMCEJ initiative. Participants were asked to consider their social justice practices as classroom teachers and the support they provided in their leadership positions to identify areas of consideration for TMCEJ. Two major themes that emerged from the data were: (a) success contingencies; and (b) design and delivery of professional development for TMCEJ. Table 7 describes the summary of findings from these themes.

Table 7

Summary of Study Findings Organized by RQ3

RQ3: What are math leaders' perceptions of professional development needs to support teaching mathematics for climate and environmental justice?
Overarching Theme: Success Contingencies ● Math leaders perceived value in, and urgency for a TMCEJ initiative because of

the drastic impacts climate and environmental changes are having on historically underrepresented groups.

- Math leaders perceived importance in the involvement of stakeholders at all levels in a TMCEJ initiative that include community members (including parents and guardians), district personnel, school-based personnel, students, and even personnel for future hiring considerations.
- Math leaders believed the school district should champion for and declare a TMCEJ initiative will be adopted along with building a solid case as to why the values of such an approach are particularly important in the mathematics content area.

Overarching Theme: Design and Delivery of Professional Development for TMCEJ

- Math leaders believed that all educational stakeholders can benefit from support in understanding the social-political issues surrounding climate and environmental injustices that accompany a TMCEJ initiative.
- Math leaders perceived that math teachers will need a lot of support to make connections between climate and environmental justice topics and critical mathematics.
- While some math leaders expressed the need for outside resources to support a TMCEJ initiative, most felt there were enough resources among internal and external stakeholders to accomplish the task.
- Math leaders believed that professional development designers need to carefully examine social justice content and intentions to prevent unintentionally

imposing a deficit approach on students.

- Math leaders believed implicit bias training should be prioritized in professional development for a TMCEJ initiative.
- Math leaders perceived the need to have ongoing professional development structures in place to support teachers with implementing a TMCEJ initiative with fidelity.

Finally, the analysis suggested an underlying theme of the curriculum as the mechanism that ultimately determines what math leaders can and cannot do in terms of instructional decision making. Originally positioned within implications for professional development, this theme was infused throughout the responses of math leaders to all three research questions warranting a separate discussion. The collective responses from participants included high stakes testing and the risk of a harmful achievement gap narrative assumed by education personnel. Table 8 describes the summary of findings from this theme.

Table 8

Summary of Study Finding Extracted Across All Research Questions

Reoccurring Finding Across Research Questions: Curriculum Limitations
Overarching Theme: State-Mandated Curriculum Limitations ● Math leaders demonstrated a constant reference to the mid-Atlantic state curriculum to determine the parameters within which they could make decisions they perceive were in the best interest of students; indicative of the institutional

power that is operative in the educational system.

- Math leaders conveyed cautious optimism about efforts towards equity that they are witnessing at the state level and the implications for curriculum and instruction that are set to be implemented within a few years.
- Math leaders perceived importance in national and state-initiated discussions about the root causes of the opportunity gap in systemic structures rather than placing the blame on individual student factors.
- Math leaders perceived importance in closely examining curriculum resources selected for a TMCEJ initiative for prescription to an asset or deficit narrative of communities of color.
- Several math leaders perceived their curriculum resources as confining and requiring extensive customization to be relevant to students' lived experiences.
- Math leaders perceived importance in focusing on alternative measures of student outcomes within a TMCEJ initiative; such as the demonstration of growth, building community, and evidence of engaging in critical thinking.

Discussion

This study employed a basic qualitative design to explore math leaders' perceptions of TMCEJ. While previous studies have examined the perception of preservice (Garii & Appova, 2013; Guerra & An, 2016) and inservice (Bartell, 2013) math teachers, the present study focused on the perceptions of math leaders. Moreover, previous studies have examined a variety of social justice topics, but they have not specifically examined the topic of TMCEJ at a district level. Thus, this study fills a gap in existing literature in two ways. First, the perceptions of math

leaders were at the center of this study. Second, an examination TMCEJ is undertaken. Table 9 describes the tentative conclusions based on the findings from this study. These tentative conclusions are presented within the context of the literature.

Table 9

Tentative Conclusions Based on Study Findings

Math Leaders' Perceptions of Social Justice Pedagogy: Implications for Professional Development on Teaching Mathematics for Climate and Environmental Justice
• Teachers presented, and supported students when they presented, generative themed topics to contextualize the dominant math curriculum and, at times, extended math lessons to support student activism. • While race is the central social construct used to build relationships in math classrooms where teachers implement social justice pedagogical practices, there may be greater opportunity to engage more teachers and students with the incorporation of socioeconomic status. • As former classroom teachers who practiced social justice pedagogy, math leaders earned the credibility and feel empowered to advocate for students of color, economically disadvantaged students, and teachers who serve these students. • Administrators and math leaders can customize support for teachers who navigate social justice pedagogy, dominant math curriculum, and administrative responsibilities; though at times district leaders themselves need support in understanding social justice pedagogical practices.

- A carefully selected group of community and district stakeholders need to be involved in the planning and execution of a TMCEJ initiative, and participate in ongoing professional development sessions to understand the social-political issues surrounding climate and environmental injustices as well as educational injustices.
- With carefully planned and ongoing district-wide professional development supports in place, such as implicit bias training, the majority of existing personnel can be vital in a district-wide curricular and pedagogical reform effort, such as the implementation of a TMCEJ initiative.
- Most Title I math teachers and leaders are not trained in social justice pedagogy and will need ongoing quality professional development and support to teach mathematics for climate and environmental justice.
- The state-mandated curriculum, and its corresponding standardized measurement of student outcomes, permeates decision making in Title I math programs that is not always in the best interest of students.
- Title I math resources are not selected based on their level of application to students' lived experiences, leading to the need for extensive customization.

The first two tentative conclusions are related to math leader's social justice practices as classroom teachers. First, math teachers presented, and supported students when they presented, generative themed topics to contextualize the dominant math curriculum and, at times, extended math lessons to support student activism. This required an understanding of instructional techniques to support students in conceptually progressing through mathematics and social justice content. This conclusion aligns with the practices of Gutstein (2003) who yielded

significant insights into using questioning as an instructional tool and supporting student engagement in math projects to understand their own realities. Math leaders had a strong understanding of their students lived experiences in classroom instruction. Consequently, they were able to produce and infuse generative themed social justice topics that reflected students lived experiences. This conclusion aligns with what Freire (1970/2005), Nicol et al. (2019), and Gutstein (2018) describe as generative themes. Math leaders' awareness of these themes were facilitated by their own lived experiences within their social constructs of race, class, and/or gender that align with the CRT tenet of intersectionality as described by Delgado and Stefancic (2017). Overall, this practice of embedding real-world topics in math instruction supports students in accessing their funds-of-knowledge (FoK), described by Moll, Amanti, Neff, and Gonzalez (1992) as the learners' knowledge base constructed from historical and cultural experiences in the home and community setting. Furthermore, math leaders were equipped with the social skills necessary to support student conversations surrounding race, and at times other inequalities when the construct was introduced by students. This finding presents an alternative view to Gutstein's (2016) description of the dilemma of "creating space for students to develop their own voices while simultaneously maintaining my own voice" (p. 486). Math leaders did not describe tensions in the presence of teacher versus student voice.

While extracting generative themes, math teachers who did engage in social justice pedagogy achieved their desired outcome of students recognizing inequalities; yet there are only few examples of this recognition translating into student activism such as the study by Gonzalez (2009). A possible reason for this is that math leaders define social justice as acknowledging "how various political, economic, and social forces continue to subordinate some groups of people and not others" (North, 2006, p. 517). As such, value is placed in emphasizing the

importance of students using the dominant math curriculum to expose and challenge inequitable social structures (Gutiérrez ,2002; Gutstein, 2003; Martin, 2003). Math leaders who did not share evidence of extending lessons to student activism may not view this extension as a necessary part of social justice pedagogy. Another possible explanation is that there could have been forms of activism demonstrated that either were not described by math leaders or may not have been interpreted by math leaders as activism.

Second, this study demonstrated that while race is the central social construct used to build relationships in math classrooms where teachers implement social justice pedagogical practices, there may be greater opportunity to engage more teachers and students with the incorporation of socioeconomic status. As classroom teachers, African American math leaders used their shared racial background to connect with their students. Study findings suggested that teachers of students that shared their racial background permitted the use of personal pronouns without explicitly naming race as the inequitable social construct. These findings align with Battey, Leyva, Williams, Belizario, Greco, and Shah (2018) who offer insight into relational interactions in the classroom setting, showing that supportive student and teacher relationship building in mathematics can have a positive impact on the outcomes of Black and Latinx student. This conclusion is also supported by a math leader sharing that Black males were not only comfortable engaging in classroom discussions, but initiating the discussions; thus a counter story to the stereotype of Black males being disinterested in engaging in mathematical discussion. Findings support McGee (2013) whose research shows that Black males can have a "keen presence of academic agency" (p. 448) that reflects their academic potential. Not only did math leaders describe classroom cultures that welcomed student voice, but they described establishing meaningful relationships with students and their families. Relationship building is

further solidified when mathematics instruction was paused to engage in trauma-informed practices because of events that occurred in the community, such as social emotional learning practices. This finding demonstrated the importance of the teacher supporting student trauma like the study presented by Onchwari (2010) on preservice and inservice teachers' demonstrating the need for teachers to be equipped to deal with student stress in the classroom environment, especially considering today's students have greater social-emotional needs.

However, math teachers who share the same racial background of students can internalize deficit approaches to the abilities of students of color. Some math leaders provided counterexamples of race as the primary source of connection between teacher and student. These findings support Milner (2020) who suggests that the opportunity gap can persist when educators' cultural practices are embedded in Eurocentric paradigms and also provided a counterexample to the racial matching theory advanced by Battey et al. (2018).

The next two tentative conclusions are related to math leaders' perceptions of navigating three educational domains: (a) dominant math pedagogy; (b) social justice pedagogy; and (c) administrative responsibilities. The third conclusion is that administrators and math leaders can customize support for teachers who navigate the three educational domains, though at times leaders themselves need support in understanding social justice pedagogical practices. The few teachers who made efforts to utilize social justice pedagogical practices constantly evaluated their ability to implement such practices. Though not without difficulty, math leaders were able to find ways to navigate the three educational domains to the best of their ability. This conclusion is at the heart of Agarwal's (2011) position that efforts to embed a social justice pedagogical approach are further undermined by accountability measures, such as high-stakes testing. Math leaders were able to use their experiences to support teachers in best implementing

social justice practices, but implied that the system is not designed to achieve such a balance. This finding was similar to the study conducted by Bartell (2013) that found that teachers embedded social justice components in increments rather than in every component of lessons in an effort to balance social justice pedagogy with the dominant math curriculum.

The fourth tentative conclusion is that as former classroom teachers who practiced social justice pedagogy, math leaders earned the credibility and felt empowered to advocate for students of color, economically disadvantaged students, and teachers who serve these students. A text search of the five interviews captured the combination of the words "best interest of students" 71 times in no particular word order. A significant example is a math leader who advocated for student progression through the Algebra I sequence to position them for advanced math. Infused in this math leaders' example is the understanding of the postsecondary opportunities that students would not have access to if they were not able to progress through this sequencing as described in the study by McGee, (2013). This math leader's advocacy also aligns with the work of Moses et al. (1989) whose equity-centered mathematics scholarship speaks to the notion of middle school Algebra I as a gateway course to accessing higher-level mathematics in K-12 education. In addition to advocating for students, math leaders advocated for teachers as a form of a social justice practice. While there is no scholarly literature to support this conclusion, the findings from this study showed that not only did math leaders support math teachers who engaged in social justice pedagogy, but they provided suggestions for how administrators could support teachers and how teachers could better navigate the three educational domains. Table 10 describes the summary of math leaders' recommendations for navigating the three educational domains to support future researchers, scholars, and practitioners.

Table 10

Summary of Math Leaders Recommendations for Navigating Three Educational Domains

Navigating Dominant Math Pedagogy, Social Justice Pedagogy, and Administrative Responsibilities		
Math Teacher Actions	*Administrator Actions*	*Math Leader Actions*
• Complete small components of all required administrative tasks. • Embed social justice topics into one lesson component. • Collaboratively plan social justice customizations of lessons. • Track student performance as evidence of positive	• Establish different priority levels for administrative tasks. • Allow flexibility in the time allowed to complete administrative tasks. • Redistribute teachers planned schedules to allow extra time for administrative task completion. • Partner with teachers to complete tasks together	• Develop positive relationships with administrators to ease advocacy for teachers. • Recognize that administrators may need support with social justice education. • Be prepared to partner with administrators and teachers to complete tasks to support student

student outcomes from social justice pedagogy.	and build relationships. ● Allow flexibility with the completion of administrative components. ● Consider multiple measures of student growth outcomes versus only accepting benchmark percentages.	outcomes. ● Advocate for building level staff at district level.

The next three tentative conclusions centered math leaders' perceptions of implementing a TMCEJ initiative. Some of these conclusions do not have literature that is a direct connection to the outcome. However, the conclusions have important implications for a TMCEJ initiative. Fifth, a carefully selected group of community and district stakeholders need to be involved in the planning and execution of a TMCEJ initiative, and participate in ongoing professional development sessions to understand the social-political issues surrounding climate and environmental injustices as well as educational injustices. A small and more privileged group within local communities can have a significant influence on decisions that impact and may not be in the best interest of the wider community. When engaging in a detailed consideration of individuals and life circumstances, many people have experienced or know someone who has experienced negative impacts from climate change or environmental pollution. However, there is concern about the ability of various community members to participate in these discussions

because of limitations such as work hours and historical exclusion from these spaces. More vulnerable community members need to participate in these discussions because climate and environmental concerns impact most persons within the communities that Title I math leaders serve, and with different levels of risk as described by Saraswat and Kumar (2016). Local and community knowledge can also be supported by a variety of stakeholders. Actors in social movements are the key determinants of what will emerge from them (Hall, 2016). Therefore, in order to support the success of a TMCEJ initiative to be successful, the entire community needs to have the same message about what the initiative is and why it is best for the wider community. The district should ensure that all stakeholders are equally represented conveying that this initiative is what is best for the district's students, neighborhood, and the environment.

Also worth consideration is that enough human capital may exist among internal and external stakeholders to accomplish the task of designing a TMCEJ initiative. The involvement of stakeholders can enhance their vested interest in the outcome of the TMCEJ initiative, potentially having a positive impact on buy-in. There is value in directing funding to support the participation from various educational personnel and even the involvement of the community in designing professional development that would be extremely valuable for extracting generative themes. This extends the research on generative themes advanced by Gutstein (2018) stating, "By engaging in its justice struggles, one will develop some of the political experience and knowledge to more deeply understand the neighborhood...in ways that genuinely connect to students' lives and the deeply felt issues of their communities" (p. 140).

It would also be helpful for all stakeholders to be presented with alternate forms of measurement to determine the effectiveness of the program. While TMCEJ is an initiative that has the potential to benefit students in all educational settings by illuminating inequalities that

exist in societal institutions, it should not be presented or measured as a tool to increase test scores or eliminate the achievement gap. Using data from standardized testing to compare the performance of students in different educational settings will always pose a challenge because until the roots of differential performance are addressed, schools that are meeting existing performance measures will continue to meet performance measures. Schools that are identified as "at-risk" will continue to work towards benchmark scores established by educational institutions. Thus, a TMCEJ initiative should focus on positively impacting a variety of student outcomes including the demonstration of growth, building community, and evidence of engaging in critical thinking. This aligns with the concept of relational equity, advanced by Boaler (2006) to describe the work of math teachers who, over a four-year period, reduced inequalities and increased achievement in the classroom environment. Findings from the research demonstrated a focus on evaluating students based on their ability to engage in collaborative learning, serving as peer role models, and supporting the learning of peers. As such, alternative measures of student outcomes were able to be used as a demonstration student progress.

Sixth, with carefully planned and ongoing district-wide professional development supports in place, such as implicit bias training, the majority of existing personnel can be vital in a district-wide curricular and pedagogical reform effort, such as the implementation of a TMCEJ initiative. Professional development on implicit bias is one of the primary professional development topics that will need to be delivered on a continuous basis. From the standpoint of teacher implicit bias, this conclusion aligns with Jackson et al. (2018) who argued that teachers need opportunities to bring awareness to their hidden biases that, if not addressed, can have a detrimental impact on marginalized populations. Professional development can support teachers with addressing their implicit biases so they can create a safe classroom environment for talking

about race and other social justice issues. For example, kindergarten teachers and community members need to eliminate the deficit mindset that students of color enter the school system with academic deficiencies. This contributes to the study by Battey and Leyva (2018) who posit the importance of disrupting deficit perspectives that impact the quality of mathematics instruction delivered to African American kindergarteners, particularly considering they enter the educational system with the same mathematical competencies as their White peers. By embracing a growth mindset, teachers and community members support young students in establishing a strong mathematical foundation and stronger outcomes along their K-12 mathematical journey. This reduces the amount of time secondary teachers spend on remediation and thereby increases the amount of time teachers can spend on implementing a social justice pedagogical approach.

Hiring is a natural part of organizational development and this conclusion includes modifications in hiring practices for staffing Title I schools to make sure that personnel have value systems that are in the best interests of students of color and students from economically disadvantaged backgrounds. Human resource personnel and principals will need to engage in implicit bias training to address their own biases and be able to filter incoming candidates for biases that may have significant impacts on student learning experiences and outcomes. Findings from this study portrayed Title I schools with a variety of student facing personnel at the school level and leadership personnel at the district level; several of whom do not have the best interest of the population of students served at the forefront of their agendas. There are personnel who chose to serve these locations because they had interest in serving students but need support with understanding the unique histories and needs of the student population. Other members of the school system have personal agendas to be satisfied and who ultimately have practices and make

decisions that are at the expense of the most vulnerable students they serve. Consequently, stakeholders at all levels in a TMCEJ initiative should be involved in contributing to the hiring process to disclose these intentions, including community members (parents and guardians), district personnel, school-based personnel, students, and even personnel for future hiring considerations.

Seventh, on the basis of these findings, it appears that most Title I math teachers and leaders are not trained in social justice pedagogy and will need ongoing quality professional development and support to teach mathematics for climate and environmental justice. Professional development would need to be designed to support math teachers in understanding and being able to support student understanding of the importance in critically examining the power of numbers using the topic of climate and environmental justice. This is consistent with various social justice research studies such as Bartell (2013) who found that careful planning of the justice learning experience helps minimize superficial connections between social justice and math topics. Such a view was also found in the study by Nicol et al. (2019), highlighting the need to deepen an understanding of mathematics to allow for broader mathematical opportunities when exploring mathematics through social justice issues. Designing the professional development from an andragogical approach would support teacher interest because the content would not only be made applicable to their day-to-day professional tasks, but presented from an entry point that validates their diverse professional experiences as described by Knowles (2012).

The final two tentative conclusions were drawn from findings that demonstrated math leaders' constant reference to the state-mandated curriculum throughout the study findings. The eighth conclusion is that on the basis of these findings, it appears that the state-mandated curriculum, and its corresponding standardized measurement of student outcomes, permeates

decision-making in Title I math programs that is not always in the best interest of students. With the correct modifications, the curriculum framework has the potential to be a powerful tool for exposing and disrupting inequities that are endemic in society. It is particularly telling that evidence from this study showed math leaders' overt and covert references to the restraint of the curriculum throughout the study. The state curriculum is the resource that math educators use to determine the essential knowledge and skills that drive instruction and assessment. One of the purposes of exploring TMCEJ is to disrupt the inequalities that exist in various societal institutions, including education. However, this research discloses a paradox that existed for math leaders. On one hand, math leaders shared classroom practices of social justice that are liberating and result in student activism, such as writing letters to their congressional representatives about environmental pollution. On the other hand, math leaders' constant reference to the curriculum is indicative of the institutional power that is operative in the educational system that confines the levels of engagement that these math leaders and math teachers desire to pursue. This study showed that in order to create an equitable frame, the narratives of all voices should be represented in curriculum resources because the content is required and accessible to all divisions and districts across the state. This finding agrees with several researchers who have questioned curriculum standards as one of the reasons that inequalities are exacerbated, due to the inequitable access to resources that include more highly qualified teachers and curriculum that is a better fit (Tate, 1995, Gutstein, 2003). The mathematics department of the mid-Atlantic state that is the setting of this study has begun the process of examining the existing curriculum to increase equity and access. Math leaders conveyed cautious optimism about efforts towards equity that they are witnessing at the state level and the implications for curriculum and instruction that are set to be implemented within a

few years. It has been several decades since the National Council of Teachers of Mathematics (NCTM, 1989) publication of the *Curriculum and Evaluation Standards for School Mathematics*, focusing on equity as an aim of mathematics reform and stating "the social injustices of past schooling practices can no longer be tolerated" (p. 4). NCTM has published the Catalyzing Change series that complements the state's equity initiative, demonstrating the progression towards providing equitable mathematics experiences for all students (Bush, 2019).

The inclusion of language that embeds inequalities within the state curriculum can help society disrupt and disclose inequitable practices in all geographical locations, even where there may be low percentages of historically underrepresented groups. Supporting documents for this study show the NCTM (2020) and other state education departments across the nation, including the mid-Atlantic state that is the setting of this study, are in the process of revising curriculum standards to include specific language stating that students of color and the economically disadvantaged do not have the same access to high quality mathematics as their peers. Several participants of this study expressed cautious optimism about such efforts unless they go further to identify and outline measures to address the practices that are the root causes of differences in student achievement and the negative consequences of standardized testing. Consequently, it is important that national and state-initiated initiatives continue to encourage discussions centering the root causes of the achievement gap in standardized test performance as a cause of systemic structures rather than individual student factors. Therefore, the complex and interrelated factors that impact educational performance can be considered (Bonner, 2011; Childs & Johnson, 2018; Martin, 2019) and student performance can be measured against a students own growth over time. This conclusion is in agreement with critical race theorists, such as Delgado and Stefancic

(2017) and Ladson-Billings (1995), who place the endemic nature of racism at the core of examining the educational system.

Finally, on the basis of these findings, it appears that Title I math resources are not selected based on their level of application to students' lived experiences; leading to the need for extensive customization. This study demonstrated reasons for curriculum selection that included the appeal of marketing strategies by various companies, branding, and individual motives by personnel who are key decision makers. As such, curriculum decisions are also impacted by the same structures that lead to institutional inequalities. Title I math professionals are losing valuable time and energies because they are required to use curriculum resources that are not in the best interest of the students they serve. Selected curriculum resources exclude the experiences of communities of color and the economically disadvantaged. Therefore, they produce more challenges for teachers who are vested in the best interest of students and therefore invest significant amounts of time customizing the curriculum to make it more accessible for students. This time detracts teachers from engaging in other professional responsibilities that can support the navigation of the three educational domains. Just as important is teachers who are not customizing the curriculum and are delivering the content to the students as is; further delaying positive student growth outcomes. This latter situation can also result in further difficulty for students accessing the required content knowledge; increasing the level of student anxiety towards the subject of mathematics. In both contexts, the curriculum resources are delivered to teachers that have not been prepared for classroom delivery. Yet the resources require extensive customization of the content to reach students in Title I schools in a manner that can best support favorable student outcomes. Consequently, it requires more work to use district required curriculum because it is not selected for the correct reasons; to support students in accessing the

mathematics from their unique funds-of-knowledge. It is worth considering the possibility of the number of resources that would become available if districts invested in curriculum resources, or personnel to create curriculum resources, that were already customized to meet the unique needs of the students they serve.

Limitations

Findings from this study expose research and practical limitations to consider for a TMCEJ initiative. The purposeful sampling of Title I math leaders limited the methodological scope of this study. Participants provided rich data on social justice perceptions, limitations, and opportunities. However, the sample profile may not have been specific enough to generate enough responses on perceptions of climate and environmental professional development needs to engage in this work. Because of the exploratory nature of this study, it is not intended to be generalizable beyond this specific population. Consequently, the research findings will not be generalizable to account for a representative of a whole group (Maxwell, 2013) and the study should be considered exploratory to understand the perceptions of math leaders on TMCEJ.

Second, there is a limitation to the study that has implications for the practicality of its applications. Evidence from this study outlines those factors that math leaders identify as limitations to the implementation of a TMCEJ curriculum. Three systemic limitations are advanced that place the greatest restraint on the extent to which such a curriculum can be designed and implemented. The endemic nature of racism and other social inequalities rooted in century-long struggles for equity and justice are present in the educational system. Furthermore, the state-level curriculum (State Department of Education) determines the parameters in which math education can be structured and is embedded within this system that has great influence over those who operate within it. In addition, school districts [senior decision maker(s) at

division level] are at various locations within the curriculum adoption cycle, and contractual obligations may pose a challenge. The study findings further reinforced the school setting as governed by larger interconnected structures that may limit such efforts to challenge inequities in a public institution. The practical application of this study is limited because of the time needed to begin and evaluate a teaching mathematics for climate and environmental justice approach, limited hiring pools available to Title I school, federal mandates, and other factors. Finally, the use of current measures of student growth outcomes are not aligned with the design of a TMCEJ initiative, and thus should not be used to determine the effectiveness of the program. The application of standardized testing after one year to determine the continuation of a TMCEJ initiative would be counterproductive to the careful planning, fidelity, and mindset change that is needed to support this initiative. To this end, this study is only as practical as the structures that permit the implementation of the findings. This study showed the most powerful variables for the practical application of a TMCEJ initiative are the individuals who make decisions about the content of the curriculum (State Department of Education) and which curriculum to adopt (senior decision maker(s) at division levels).

Implications

The focus on math leaders in Title I schools was unique to this study to examine math leaders' perceptions of teaching mathematics for social justice and the implications for a TMCEJ initiative. Partnering with this study population allowed very specific responses from classroom teachers who moved up to decision-influencing positions in locations receiving federal funding to support successful student outcomes on standardized testing. The tentative conclusions that emerged from this study demonstrate potentially favorable outcomes when engaging in research

on and considering the practical application of infusing mathematics in a climate and environmental justice curriculum.

Practical Implications

First, the study implies the need to closely examine curriculum for ways that the content may hinder or support mathematical knowledge that is in the best interest of all students who are impacted by its reach. This study demonstrates that the curriculum framework has successfully achieved its purpose of serving as the default source for guidelines within which math personnel frame their instructional supports and creators of curriculum resources develop mathematic instructional materials for teachers and students. However, if social justice is not central to the curriculum, then it will never be a priority. Therefore, the math leaders who oversee the modifications of the state curriculum have a great responsibility to ensure the curriculum is inclusive of language that supports students in acquiring mathematical knowledge, while at the same time works to disrupt the inequities that are so deeply infused within society and have significant impacts on members of society. In order to do so, the terminology embedded within the essential knowledge and skills of the curriculum will need to identify specific social constructs, examples of the constructs, and how the practical application of the construct would be demonstrated within real-world problems. As such, conversations about race and racism and the intersection of other social constructs within the curriculum are required to master the curriculum.

In doing so, the second implication is the need to examine and modify the current standardized measures of student outcomes to center the variety of student lived and educational experiences. Data triangulation is necessary, but should not be based on various forms of standardized measures from different sources. Teachers, administrators, and district personnel

are emphasizing assessment results and teaching to the test which sets a low standard of achievement (a minimum score), rote instruction, and does not allow space for students to truly learn the power and the "why" behind mathematics. Pedagogy that demonstrates positive outcomes for students of color and the economically disadvantaged are not accurately measured by the existing forms of measurement that are produced by standardized testing.

Third, this study implies the need to evaluate current practices of curriculum selection. Curriculum customization is time consuming and results from this study showed that math leaders and teachers are spending resources of time and money on customizing the curriculum. Curriculum that is not selected based on students' lived experiences leaves room to question who selects current curriculum resources, why existing resources are selected and therefore warrant a thorough evaluation of current processes in place to examine curriculum selection. It implies the need for procedures to ensure that a TMCEJ initiative has a process of vetting curriculum that can result in favorable outcomes and serve its intended purpose.

Fourth, there is an implication from this study that staffing is an important consideration for effectively implementing a TMCEJ initiative. A carefully vetted team of individuals is needed to oversee the critical components of this initiative. Regardless of internal or external candidates, the members of this team cannot be selected on the basis of nepotism or the ability to provide the most favorable responses to the human resource personality assessment. This is also important when considering community stakeholders who would support the initiative and district personnel who would deliver various components of the initiative. Findings from this study imply that human resource personnel and administrators need have practices in place to ensure that candidates who are a better fit are attracted to work with a TMCEJ initiative. These structures can include supporting hiring personnel with screening techniques to filter candidates,

developing extremely competitive salaries, and involving a variety of stakeholders in the candidate interviewing process. Such practices have the potential to create a diverse group of personnel from a variety of cultural backgrounds who are excited about the potential for a TMCEJ initiative. There are professional development recommendations that emerged from this study to support stakeholders in the implementation of a TMCEJ initiative at the district level. These recommendations have utility for district-level personnel and include components that can support other stakeholders with the proposed considerations.

Table 11 describes district-level recommendations for a TMCEJ Initiative (see Appendix E for Online Resources to Support A TMCEJ Initiative). These include professional development for teachers on content such as environmental literacy for teachers to be able to implement this initiative.

Table 11

Math Leaders Recommendations for A District Level TMCEJ Initiative

Implementing a TMCEJ Initiative at the District Level
When considering the implementation of a district-level TMCEJ initiative, key stakeholders should…
• Explicitly commit to adopting and implementing a TMCEJ initiative. • Establish a clear value position so all stakeholders can communicate the same goals of the initiative. • Ensure representation in the TMCEJ initiative across all levels of the local community including: (a) the community level (parents); (b) district level (central office personnel); and (c) the school level (administrators, teachers, and students).

- Approach professional development for TMCEJ as a collective initiative by offering it to all stakeholders who are not indirectly or directly involved with math instruction.
- Mandate the TMCEJ professional development program for all stakeholders who are directly or indirectly involved in the TMCEJ initiative.
- Construct the professional development to support the needs of different stakeholders but with the same overarching goal of using mathematics to perform a critical analysis of inequalities infused in climate and environmental injustices and develop a justice response.
- Support human resource staff and administrators in screening incoming candidates for value systems that are extremely disconnected from the districts vision.
- Involve representatives from all stakeholder groups, including student panels, to vet incoming candidates for best fit.
- Provide options for district staff who are not a good fit for a TMCEJ initiative.
- Implement measures to support existing district personnel with recognizing, evaluating, and appropriately responding to their implicit biases.
- Develop and share across the district multiple measures for student growth outcomes in addition to standardized testing.

Theoretical Implications

From a research approach, findings from this exploratory study confirm and have the potential to expand scholarship on teaching mathematics for social justice. First, research studies show that teachers struggle with balancing implementing a social justice pedagogy, dominant

math instruction, and administrative tasks (Agarwal, 2011; Bartell, 2013). The results of this exploratory study support the difficulty that teachers have with navigating curriculum, task, and pedagogical practices as classroom teachers. However, the source of this challenge is situated within the structure of the system.

Second, this research contributes to scholarship on teaching math for social justice by incorporating the perspectives of math leaders who were former math teachers in the classroom environment that engaged in social justice pedagogy. This is an extension of social justice mathematics literature that surrounds the work of preservice (Garii & Appova, 2013; Guerra & An, 2016) and inservice (Bartell, 2013) math teachers. This study describes how math leaders, as former classroom teachers, had gained confidence in their practices to describe ways of supporting existing classroom teachers with this navigation. Some strategies advanced to support math teachers with balancing the three educational domains included collaborating with fellow teachers and tracking evidence of a variety of positive student outcomes.

Finally, this study contributes to academic scholarship by examining climate and environmental justice as a specific social justice topic. Schlosberg and Collins (2014) identify three conceptualizations of climate justice: (a) elite non-governmental organizations (NGOs) that focus on policymakers promoting a voluntary, economical approach; (b) the grassroots climate justice movements that focus on addressing the fossil fuel industries' inequitable impacts by supporting the most vulnerable communities; and (c) academic scholarship that primarily centers on intergenerational justice and is void of a critical race lens that examines the alarming impact of this crisis on the most vulnerable communities (Black, 2016; Shelby & Kagawa, 2018). There is the need to redefine and reframe the climate crisis (Hall, 2016) as a civil rights concern to understand how people of color and the economically disadvantaged are disproportionately

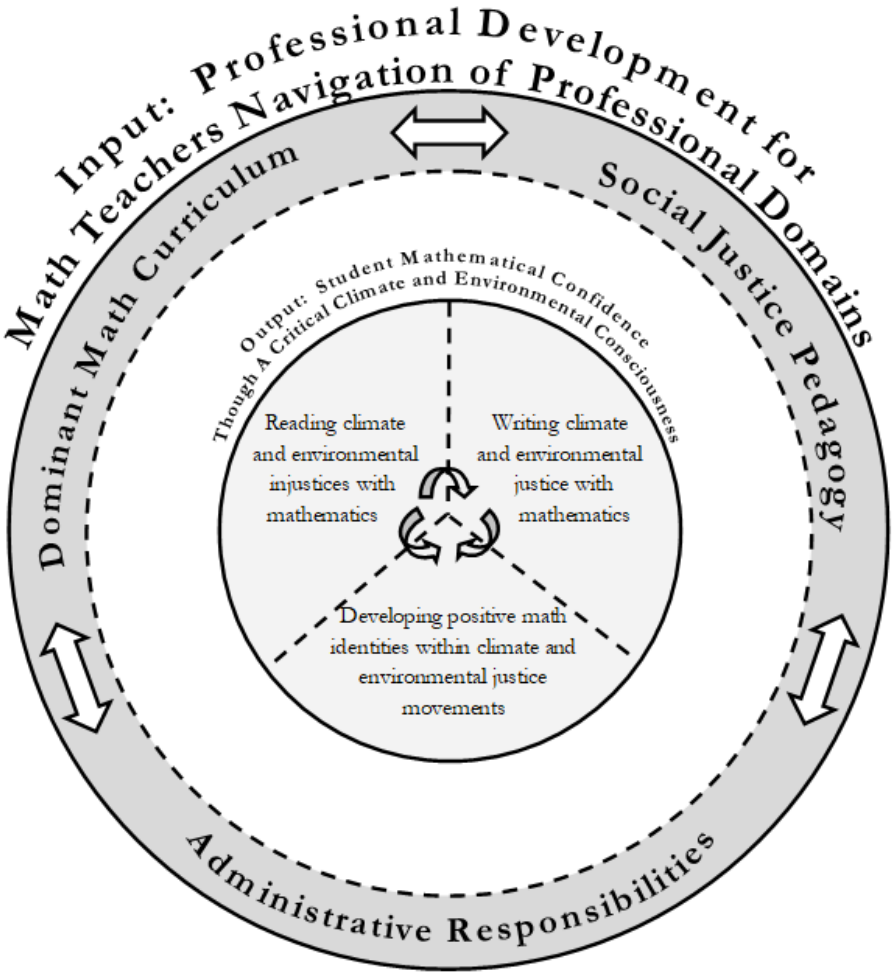
targeted and affected by the pursuit of ownership and maintenance of economic prosperity for the wealthy. Therefore, this study is a theoretical contribution to climate justice scholarship as an issue centered on racism and classism.

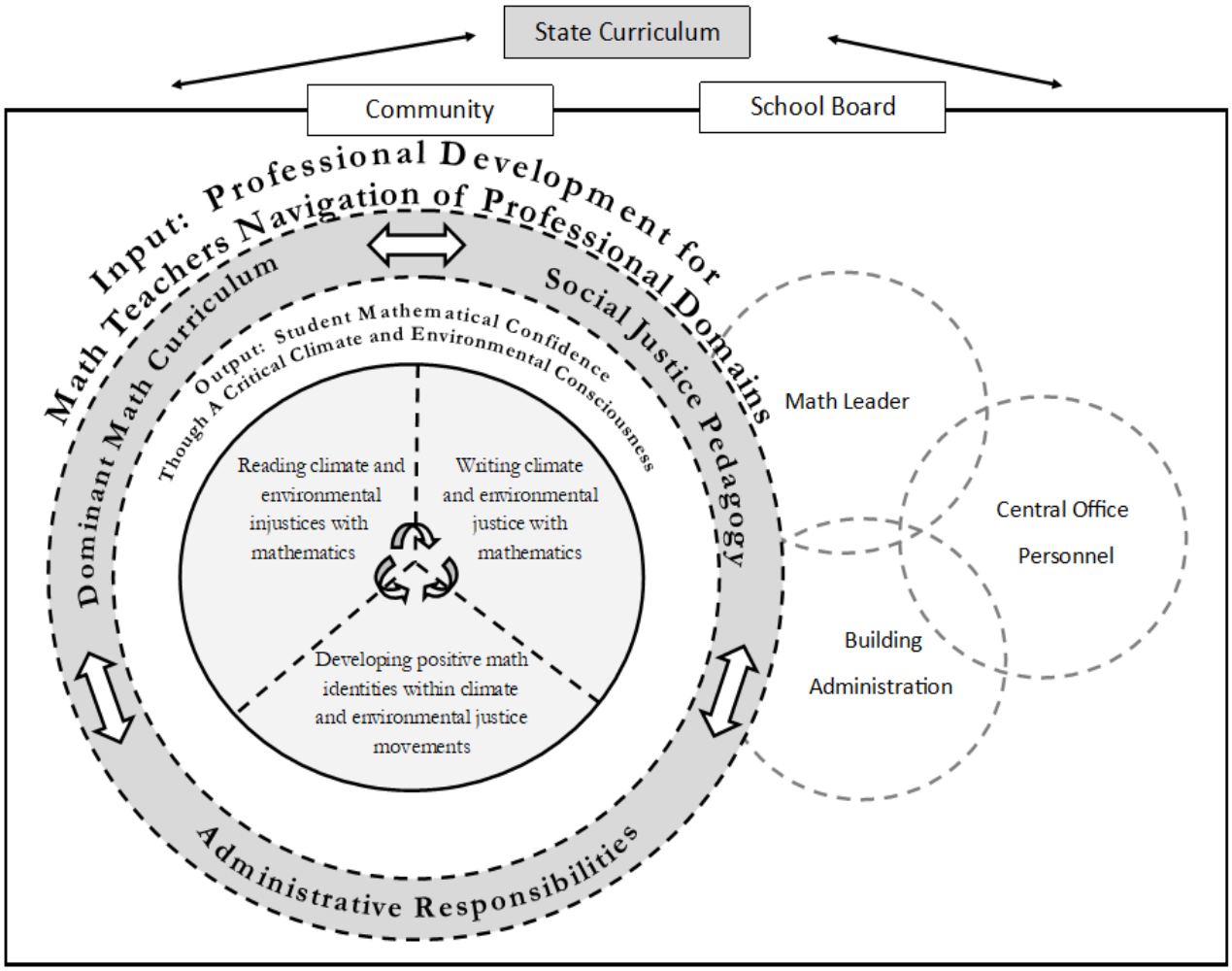
Revised Conceptual Model

The initial conceptual framework devised for this study aligns with the majority of the themes that emerged from the data (see Figure 2). The conclusions and implications from this study warranted the revision of the original conceptual framework to reflect the broader factors at work that may significantly impact professional development for TMCEJ. Accordingly, the conceptual framework was modified to include the three leadership areas within the school districts that would impact this initiative as math leaders, central office personnel, and building administration. This study also disclosed the need to include three additional components that represented policy and decision-makers on the peripheral of the district level including the State Department of Education (the State Curriculum), school board, and community members (including parents and guardians of students). Consequently, it is recommended that both conceptual frameworks be considered, but the second framework as an extension of the first. It is also helpful to consider an examination of the two conceptual frameworks advanced from the teacher lens and the math leader's lens. Specifically, the conceptual framework devised from the teacher's standpoint includes three parts: (a) math pedagogical, (b) social justice practices, and (c) administrative responsibilities. Previous research supports the balance required for teachers to effectively navigate these three responsibilities. If a professional development program supporting TMCEJ is implemented, this framework can be considered for ways that it can be applied and adjusted as necessary to move these conversations forward.

Figure 9

Initial and Revised Conceptual Framework





Recommendations for Future Research and Practice

The body of knowledge for teaching mathematics for social justice remains current with emphasis on supporting students with building agency and focusing on an asset or opportunity approach as opposed to an achievement gap (Gutiérrez, 2008). An asset approach takes into consideration the complex and interrelated factors that impact educational performance (Gutiérrez, 2008; Childs & Johnson, 2018; Martin, 2019; Bonner, 2011). This study resulted in recommendations for future research and practice.

Based on the findings from this study, there are opportunities for future practice for teaching mathematics for climate and environmental justice. First, until math curriculum is identified that represents students lived experiences, it is recommended that math leaders adjust their scheduling to allot time to customize lessons for the district. Similar to teacher collaboration, it is recommended that math leaders' partner with other math leaders to customize these lessons that will help teachers reduce the amount of time lost from developing and framing lessons around real-world topics in isolation. Second, it is recommended that math leaders consider conversations with science leaders to exchange ways to collaborate and exchange ideas about how to embed mathematics in students lived experiences. Climate change and environmental consequences of human behaviors are embedded in the middle school curriculum of the mid-Atlantic state that is the setting of this research. Therefore, science leaders may be able to provide a unique view of real-world application with or without a social justice lens.

In terms of future research, math leaders have developed generative themed social justice topics that they draw from to support their students in contextualizing math content during learning activities. Almost half of these topics could be classified as topics that fall within climate and environmental injustices, such as asbestos in school buildings and the impact of environmental pollution on economically disadvantaged communities. Math leaders showed that as classroom teachers, they developed skills to support students in identifying operative social constructs when presented social justice topics. Future research could explore other topics that math leaders have organically infused in their social justice practices for the purpose of cataloging for frequency and support of practical implications.

Considering the need for a deeper exploration of environmental literacy, the recommendation is also advanced that future research expand the sample profile to include

science leaders who have taught for climate and environmental justice. This extension of the sample profile may allow a greater number of participants to provide their unique experiences with teaching social justice in the classroom environment. These same leaders could then participate in a focus group to discuss their perceptions on professional development needs and considerations for a TMCEJ initiative or a combined science and mathematics initiative.

In addition, future research could examine the strategies that math leaders implement that successfully support students in identifying the social construct or constructs operable in particular situations. While findings show these are practices that math leaders learned from years of mathematics instruction with historically underrepresented groups, there are potential benefits for professional development to support educational staff with contextualizing justice experiences in mathematics education.

Furthermore, curriculum limitations were only merely uncovered by this research study yet have important implications for future research and practice. The current social-political climate is showing evidence of the shift in societal structures towards the practical application of equity within mathematics. Evidence from the findings of this study demonstrated a mid-Atlantic state moving towards curricular modifications to impact equity and access of all students to mathematics, including the participation of a broader group of stakeholders. Consequently, there is a research opportunity for a closer examination of how these structures specifically address the endemic nature of inequitable social constructs. Math leaders at the state level can provide insight into this, including an examination of the policies that are in place by the state board of education and how they hinder and advance the equitable mathematics movement.

Finally, the theoretical framework could also have used an organizational learning or social justice leadership theoretical lens, as demonstrated in the revised conceptual framework.

An organizational learning lens could support the consideration of the technical aspects of a system-wide approach to TMCEJ as a system-wide initiative. A social justice leadership theoretical lens could provide considerations for supporting leadership with implementing a TMCEJ initiative. The recommendation advanced is for future research to explore the perceptions of individuals, if any, who have matriculated to the highest positions in math leadership in the state and engaged in social justice pedagogical practices as math classroom teachers. Not only might it benefit scholarship by exploring their perceptions on a TMCEJ initiative, but it would be beneficial to understand their perceptions of the ways, if any, the existing curriculum framework can be modified to embed social justice practices.

Conclusion

This study explored Title I middle school math leaders' perceptions of professional development considerations for a TMCEJ initiative. The tentative conclusions that emerged from this study demonstrated potentially favorable outcomes when engaging in research on and considering the practical application of infusing mathematics in a climate and environmental justice curriculum. Using this study as a platform, math leaders shared rich stories of relationship building with students and their families that helped to strengthen the depth of their classroom communities to support courageous conversations about social injustices within an educational system that is not designed for the success of students of color and the economically disadvantaged. Several of these topics centered climate and environmental injustices. As classroom teachers, math leaders infused injustice into their pedagogical practices and favored the proposed practice of a TMCEJ initiative, sharing important considerations such as hiring and retention practices, stakeholder buy-in, curriculum resources, and using various indicators as measures of success. This study also illuminated the limitations of the existing curriculum when

advancing social justice pedagogical efforts. The social justice champions in this study conveyed that the current social-political climate projects a readiness for a TMCEJ initiative. Structural change of the educational system should occur at the state level to be impactful, which is why a TMCEJ initiative should not be used as a solution to the achievement gap in standardized test performance. However, local level educational systems can consider a TMCEJ initiative with alternative measures of student outcomes such as the demonstration of growth, building community, and evidence of engaging in critical thinking. In turn, evidence from this study brought to light the potential value of a TMCEJ initiative for students in all educational settings as it is a method of using mathematics to disclose two very real and detrimental events; societal oppressions based on social constructs (e.g., racism and classism) and climate and environmental change.

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APPENDIX A: ELIGIBILITY / DEMOGRAPHIC INFORMATION SURVEY

Please answer the demographic questions below. This general information will only be used to confirm you meet the study requirements and help gain a better idea of the characteristics of the study sample if you meet the study requirements. If selected to participate in the study, your answers will not be connected to you or your place of employment. Your name, place of employment, and school district will be replaced with a pseudonym.

1. What is your name and email address?_____

2. How many years did you teach math in the classroom? (*only include years when you taught from the beginning of the school year until the end*)
   □ 1-3 □ 4-6 □ 7-9 □ 10-12 □ 13+ □ I did not teach math in the classroom setting

3. Which of the following best describes the grade level(s) that you taught math in K-12? (*check all that apply*) □ P-5 □ 6-8 □ 9-12 □ I did not teach math in the K-12 classroom setting

4. Were you a math teacher in a Title I middle school?* □ Yes □ No
   If yes, what state(s)?_____

5. Are/were you a math leader in/of a Title I middle school?* □ Yes □ No
   If yes, what state(s)?_____

6. At which level(s) are/were you a math leader? (*check all that apply*)
   □ School □ District □ State □ Federal □ Other: _____

7. What is/was your job title as a math leader? _____

8. What are your licensure endorsements and certifications?_____

9. What gender do you identify as? □ Male □ Female □Other_____ (*check one*)

10. What is your age? □ 20-29 □ 30-39 □ 40-49 □ 50+ (*check one*)

11. Please specify your ethnicity. (*check one*)
    □ Hispanic/Latina/o □ Black/African American □ American Indian/Alaska Native
    □ Caucasian / White □ Asian/Pacific Islander □ Other_____

12. What is the highest level of education you have completed? (*check one*)
    □ Bachelor's Degree □ Master's Degree □ Degree beyond a Master's

*The federal government designates a Title I school as a school that receives additional federal funds to assist with instructional and related resources based on the high percentage of students eligible for free and reduced lunch (www.ed.gov).

APPENDIX B: INTERVIEW PROTOCOL

INTERVIEW SCRIPT

Thank you for agreeing to speak with me. My name is Angela Allen, and I am here as a part of my research on teaching mathematics for social justice. Before I begin, I want to tell you more about the purpose of my study and the types of questions I will be asking.

OVERVIEW OF STUDY

My hope for this study is to learn more about your perceptions of using math as a tool for students to recognize and analyze social injustices in their lives. I am asking you about your experiences because I believe they will provide the most accurate and honest account of how this practice looks in different classrooms. I am also interested in how this practice influences your views on teaching math for climate justice. There are no right or wrong responses because I am interested in learning about your unique perspective.

CONFIDENTIALITY

There will be no potentially identifiable information about you in the interview notes or recording collected for this study. Quotes from your interview may be included in the write-up of this study, but I will never use your name. I will always use a pseudonym. I also ask that you use a pseudonym if referring to other individuals during this interview process. If your name, another individuals name, or other identifiable information is used during today's interview, they will be removed from the transcript and the recording. I will also use a fake name to identify your workplace and the city and school district where you work, so anyone reading this report will not know who you are. I hope that you will feel comfortable speaking honestly about your experiences. Just as I will protect your confidentiality, I ask that you keep what we discuss in our interview today private by not discussing our conversation with anyone else.

RECORDING

Today's interview should last approximately 90 minutes. With your permission, I will audio record our conversation so I can accurately capture what you share. Your real name and recordings will never be shared or listened to by anyone other than me.

RESEARCHER

Before I begin, I would like to share a little about myself: a) Place of birth, b) teaching experience, c) leadership experience, d) commitment to social justice education, e) interest in green jobs and climate justice

- Do you have any questions before we begin?

INTERVIEW QUESTIONS

Professional Description: Thank you for allowing me to share a little about myself. I will transition to ask you a few questions to give me an idea of your identity as a math leader and your role in a professional context.

- Can you tell me what your job entails?
  - *Probes*: What are some of the challenges or strengths of the work that you do?
- How many years have you worked in your current position?
- Aside from classroom teacher, did you work in any other roles before assuming your current position?

Social Justice Practices as a Classroom Teacher: Now, we will have some conversations surrounding your social justice practices. Think about your work when you were in the classroom.

- Can you tell me a time or two when a conversation about race surfaced in your classroom?
- Have you ever found ways to integrate race into your math instruction? Think of a specific time when this happened and share the details of this experience.

➢ Probe: What led to the integration of race?
➢ Probe: Could you walk me through how the lesson unfolded.
➢ Probe: How were the students responding?

Balancing Professional Responsibilities: Let us take this discussion a little further and bring in your current job responsibilities. For this part of the interview, we will talk about your navigation of teaching the required math curriculum, using instructional strategies to bring students' lived experiences into the classroom, and meeting administrative responsibilities. I would like to first read a vignette to you, a short story about a hypothetical person.

> *Ms. Taylor is a third-year math teacher who had great success with student engagement and performance on district assessments. However, you notice a change because her students are starting to perform poorly on these same assessments, and there is a difference in their level of engagement. You talk to Ms. Taylor, who shares that she no longer has time to plan her social justice lessons that were the source of student engagement and performance. She is now "teaching to the test," but it does not provide her with the results she had before. Her time has been consumed by the need to analyze district data, attend lesson planning, district, and school-based meetings, call parents, pull students for small-group remediation, and more. She is even more stressed because*

her administrator has placed her on a performance plan because of her students' poor performance.

Ms. Cameron is Ms. Taylor's administrator. She noticed that Ms. Taylor started the year off strong, but now there is a difference in her students' performance. Ms. Taylors last few observations show a decrease in student engagement, less of a focus on real-world application (e.g., going shopping at the mall, calculating the area to cover a box, measuring shadows), and students scoring poorly on assessments. Ms. Cameron has offered Ms. Taylor several resources with techniques to increase student engagement, provided lesson plan feedback with general real-world examples, and instructed her to provide evidence of remediating students. Ms. Cameron has placed Ms. Taylor on an improvement plan because even with the supports in place for Ms. Taylor, there has been no improvement.

- Please share a few things that have flooded your mind as you listened to this vignette.
- Can you tell me about a time when you, as a math leader, had to support a teacher with this balance?
    - Probe: What led to this moment?
    - Probe: Could you walk me through how you offered support?
    - Probe: How was the teacher responding?
- What about a time when you, as a math leader, had to support an administrator with this balance?
    - Probe: What led to this moment?
    - Probe: Could you walk me through how you offered support?
    - Probe: How was the administrator responding?
- Can you think about a story to share about a teacher effectively balancing teaching math content, engaging students with lessons related to their race/ethnicity, and administrative tasks such as pacing, assessments, and meeting Teacher Performance and Evaluation System goals?
    - Probe: Please be as detailed as possible. Could you walk me through how the teacher effectively balanced these tasks?
    - Probe: Was anyone else there when this was happening?

Teaching mathematics for climate and environmental justice: Now, there is another issue that I want to ask you about. I want you to think about when you make curriculum and instructional recommendations and decisions for your district. We are going to look at the potential for teaching math centered on climate and environmental justice topics. For this part of our interview, we will look at opportunities for establishing professional development for supporting teachers on these topics.

- Please share your thoughts to the "Freedom to Breathe" videos.

Now I'm going to move into a vignette that is about the same topic. I'd like to read a vignette to you. It is based on a true story.

A major energy company wanted to build a compression station in a small African American community in Buckingham County, VA. Compression stations are needed to maintain the pressure to move natural gas through pipelines. However, they negatively impact members of the local community, who are primarily people of color, such as releasing toxins in the air that cause asthma and cancer-causing agents already overly prevalent in communities of color. Our neighbors in Buckingham County, VA, banned together and were able to stop the construction of the Atlantic Coast Pipeline, speaking volumes about the power of communities who ban together in efforts to stop environmental and climate and environmental injustices. K-12 children in Buckingham County experienced this impactful movement in their same community. Mrs. Brown, Mr. Smith, and Ms. Wallace are three math teachers at different schools who approach you about centering the math curriculum framework in various climate justice topics impacting local students' lives like the Atlantic Coast Pipeline. They make a strong case that it would build student interest, make math relevant, and continue the momentum of students having positive identities because of the empowering experience of stopping the construction of the compression station in their community. They firmly believe that it can have a positive impact on student learning outcomes.

- If you were in this situation, how would you respond?
- What would be necessary at the district level to support these teachers who want to make math content relevant to the student's community experiences?
  - Probe: What professional development needs should be taken into consideration?
  - Probe: What would be necessary for something like this to take place in your district?
- Tell me about a time when you, as a math leader, proposed a change or suggested instructional supports that centered around race.
  - Probe: What led to this?
  - Probe: Was anyone else involved in proposing or making decisions about your suggestion?
  - Probe: How did they respond?
  - Probe: How did you feel about the outcome?

APPENDIX C: STUDY INVITATION

RE: Math leaders invited to participate in a study on teaching mathematics for equity, access, and social justice

Dear Math Leader,

My name is Angela Allen and I am a doctoral student in the School of Education at Virginia Commonwealth University. I am conducting a research study on how math leaders practice equity, access, and social justice in K-12 math education and possible implications for teaching mathematics for climate and environmental justice. I am interested in learning more about your practices if you:

- Have taught mathematics for equity, access, and/or social justice*
- Are a current or former math leader
- Have a minimum of one-year experience teaching math in the classroom setting
- Have at least one year of teaching or leadership experience in a Title I middle school

You are receiving this email because you are a K-12 math leader and I want to extend this opportunity for you to share your voice. Participation is voluntary. If you would be willing to share your experiences with me, please click here to fill out this short eligibility survey by [DATE].

Based on your responses, I will invite some math leaders to participate in the full study to be conducted between February and March 2021. The full study involves watching a brief 25-minute video series and engaging in a 90-minute audio-recorded interview via Zoom.

Thank you for your interest and for considering my request. If you have any questions, please contact me at [EMAIL ADDRESS].

Sincerely,

Angela Allen

*For this study, teaching math for social justice is defined as supporting students in using mathematics to a) critically examine unjust social, political and/or economic structures and/or b) consider ways they can participate in transforming these same structures at the local, national, and/or global levels. This definition is influenced by the work of North (2006) and Westheimer and Kahne (2004).

APPENDIX D: PARTICIPANTS NEXT STEPS

Dear [PARTICIPANT],

Thank you for your willingness to participate in the study on Math Leaders' Perceptions of Social Justice Pedagogy: Implications for Professional Development on Teaching Mathematics for Climate and Environmental Justice. I am excited to learn more about your experiences with equity, access, and justice in math education. The following are the next steps to prepare for our conversation.

1. Click here to watch, *Freedom to Breathe*, a brief PBS collection of five videos about climate justice that runs for a total of 25 minutes.
2. On "Day, Month, Day, Year" at "time," "Click here to access the Zoom Link" for a discussion about your experiences with equity, access, and justice in the math classroom. The conversation will last approximately 90 minutes.

Participation in this research study is completely voluntary and you may withdraw at any time. If you would like more information, or if you have any questions prior to our arranged meeting date, please feel free to contact me via email, [EMAIL ADDRESS], or call [PHONE NUMBER].

Best,

Angela Allen

APPENDIX E: ONLINE RESOURCES TO SUPPORT A TMCEJ INITIATIVE

Teachers for Climate Justice

PBS Peril & Promise: The Challenge of Climate Change

Rethinking Schools

Zinn Education Project: Teach Climate Justice Campaign

The Environmental & Climate Justice Studies Digital Hub

Learning for Justice

Youth on Board

Teach Climate Justice